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THE ROYAL SOCIETY OF NEW SOUTH WALES

OFFICE BEARERS FOR 2005-2006

The Society originated in the year 1821 as the Philosophical Society of Australasia. Its main function is the promotion of Science by: publishing results of scientific investigations in its *Journal and Proceedings*; conducting monthly meetings; organising summer science schools for senior secondary school students; awarding prizes and medals; and by liason with other scientific societies. Special meetings are held for: the Pollock Memorial Lecture in Physics and Mathematics, the Liversidge Research Lecture in Chemistry, the Clarke Memorial Lecture in Geology, Zoology and Botany, and the Poggendorf Lecture in Agricultural Science.

Membership, as an Ordinary, Associate or Absentee Member, is open to any person whose application is acceptable to the Society. An application must be supported by two members of the Society. Subscriptions for the Journal only are accepted. The Society welcomes, from members and non-members, manuscripts of research and review articles in all branches of science, art, literature and philosophy for publication in the *Journal and Proceedings*.

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President's Column

JAK KELLY

Why are we here?

Aside from this thought occurring to those of mature years when we go down to the garage and forget on the way what we came for, it is a serious question that all organizations must confront from time to time. On several occasions in the long and illustrious history of our Royal Society there have been those who could not find an answer and suggested that we should just fade away.

We were for a considerable time *the* scientific society in Australia. This has changed over the 184 years of our existence, partially due to our ideas and efforts. Our suggestion, and follow up efforts, that there should be a university in Sydney, for example, seems to have turned out well. Scientific specialities such as chemistry, physics and the rest have formed their own societies with their own meetings and publications, so what is left for us to do? We should remember that we were originally a meeting place for those interested in the rational investigation of nature, both for its intrinsic interest and, importantly for a struggling isolated colony, to discover new resources that could economically support the country. The discovery of gold and coal are two continuing contributions that our members have made.

OK that was yesterday but what have we done today? We have always acted to show science as one of humanities most interesting and effective activities and this is still our central role today. At a time when there has rarely been a greater need to defend it from ideological attack and the public fear that this propaganda engenders. Fundamentalists of various religious persuasions are reviving heresy trials which can have you executed or merely sacked, depending on which country you are in. American states are trying to remove evolution from schools. Fear campaigns of the dangers of nanotechnology or stem cells are having some success.

Strong emotions like fear and anger play well on TV and make better headlines than the unadorned truth. Even positive media coverage of a scientific achievement often leaves much to be desired. To me, "scientific breakthrough" conjures up images of Hagar the Horrible & his henchmen, in white lab coats with a battering ram knocking down a door to get at the secret formula. The need for more rational thought is clearly great. Let us hope we can continue to influence people in that direction.

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AUSTRALIA

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Presidential Address delivered before The Royal Society of New South Wales on 6th April, 2005

A Hundred Years after Einstein's Extraordinary Year

KARINA KELLY

Keywords: Einstein, science funding

Biography: Karina Kelly is the retiring President of the Royal Society of New South Wales; a position she has held for two years. It is a long standing tradition of the society that each retiring president gives a presidential address on a subject of their choice and this is one such. Karina has worked in television since 1981, first for the news department of SBS television, then Channel 7 news before joining ABC's TV science program Quantum in 1986. She left ABC in 1996 and spent five years at home with her children before re-joining ABC's Catalyst program in 2001. She has won numerous international awards for her television work, including a World Gold Medal at the New York Film and Television Festivals.

It's a hundred years since Albert Einstein had his 'extraordinary year', known by the Latin, 'Annus Mirabilis'. In 1905, he published several papers that would change the way we see the Universe forever. It was so remarkable that to mark the centenary of Einstein's work, 2005 is the World Year of Physics. The range of subject matter of these miraculous papers was staggeringly large. They would seed research in many areas of physics and help engender a wild enthusiasm for science throughout the twentieth century. Einstein himself became a hugely popular figure in his own lifetime — an exceptional achievement for a scientist in any age. It would be some time before Einstein, or anyone else, would come to understand just how remarkable his output that year was. But then, as Einstein knew only too well, time is a relative thing.

His first paper of 1905 was completed on 17th March and was in Einstein's own words, 'revolutionary'. In this paper, with the uncharismatic title 'On a Heuristic Viewpoint Concerning the Production and Transformation of Light', Einstein first put forward his theory that light was divided into 'quanta' which we now call photons. Newton had believed that light came in little bundles but by 1900 observations had shown that light behaved like a wave. By assuming that light *also* consisted of discrete packets, Einstein predicted the photoelectric effect, that changing the frequency of light would change the energy of electrons dislodged by it.

But this theory contradicted the wave theory of light which assumed that energy is infinitely divisible. This strange property of light to behave sometimes like a wave and sometimes like a particle, called wave-particle duality, formed the foundations for the development of quantum mechanics, which Einstein ironically never found satisfying. He proclaimed in a letter to Max Born in 1926 his conviction about how God would organise things. 'I, at any rate, am convinced that He does not throw dice.' This work would earn Einstein the 1921 Nobel Prize for Physics.

Just over a month later, Einstein finished his doctoral dissertation to the University of Zurich. On 30th April (after much delay) his 'New Determination of Molecular Dimensions' used the viscosity of a sugar solution to determine the size of sugar molecules. Curiously, this is Einstein's most cited work from 1905.

Then, on May 11th, the *Annalen der Physik* received another paper from Einstein. This was his 'Brownian Motion' paper where he theorises that small particles suspended in water should show a random movement under the microscope caused by the kinetic energy of heat. If this is observed, Einstein predicted, it would also provide evidence of the existence of atoms.

As if this all wasn't enough, in June the *Annalen* received another paper from the prolific young Einstein; 'On the Electrodynamics of Moving Bodies' (or in German 'Zur Elektrodynamik bewegter Körper'). This paper introduced what came to be known as the *special theory of relativity* which combined time, space, mass and energy. It challenged the ideas that time and size are immutable and was received with not just scepticism but ridicule.

It was to captivate the science world and the broader community for the rest of the century.

Then, on 27th of September, Einstein produced his last remarkable paper for 1905.

Called 'Does the Inertia of a Body Depend Upon Its Energy Content?', it deduced one more aspect of his relativity theory. This was his famous equation $E = mc^2$. But if you read the original paper that equation is nowhere to be seen.

What he writes is 'If a body gives off the energy L in the form of radiation, its mass diminishes by L/V^2.' So there you have it. The $E = mc^2$ paper doesn't contain the famous formula.

In fact it would be written as $m = L/V^2$ if you followed Einstein's notation. V was the label he gave the speed of light in 1905. And $m = L/V^2$ is simply not as delightful as $E = mc^2$ as I'm sure you'll agree.

I hope I haven't ruined your day by telling you that. Anyway no matter how it was written, this was the remarkable equation which demonstrated that matter could be converted into energy and energy could be converted into matter. Even more remarkable was the huge amount of energy (mostly in the form of light and heat) that could be derived from a very small amount of matter. It wasn't until the 1930's that people made the connection that this theory could help to make one hell of a bomb.

I'm not sure what it says about humanity that we managed to turn the Equation into a real live bomb in a matter of decades but pursuing the great questions of what the universe is made of and how it works didn't get quite the same financial or political support. Perhaps Einstein himself could shed some light on this. This statement is attributed to him.

'Only two things are infinite; the Universe and human stupidity and I am not sure about the former.'

In Douglas Adams' *Hitchhiker's Guide to the Galaxy*, (soon to be a minor motion picture) the computer 'Deep Thought' took seven and a half million years to come up with the answer 'to the great question of Life, the Universe and Everything'. The answer, of course, was 42. From the late 1970's, we had our own ambitious 'Deep Thought' experiment. To build the grandly named Superconducting Supercollider even more grandly known as 'the window on creation' by enthusiasts. It was to be built at Waxahachie near Dallas, Texas.

It was hoped that by smashing protons together at an energy of 40 trillion electron volts, it would help us understand if particles are really vibrating membranes which exist in more dimensions than we may care to contemplate. It might also have detected a particle called the Higgs boson, which sounds like something that belongs in the *Hitchhiker's Guide*, but is very important to physicists because according to the Standard Model of Particle Physics it should exist.

All exciting stuff, but unfortunately with US$2 billion spent and a very large hole in Texas already dug, the US Congress cancelled the project in 1993. Their reasoning was that the eventual price tag of $12 billion dollars was too much to spend to find out more about the Universe. It would have provided 7,000 jobs, more than a hundred US universities wanted to be part of it, and 23,000 students had enrolled in courses that involved the eagerly awaited Superconducting Supercollider.

For a long time, the $2 billion hole did nothing more than store a lot of styrofoam cups but according to BBC online, the site is now being used for anti-terrorism firearm training.

There's no doubt that $12 billion is a lot to spend on a large physics experiment. But let's compare it with the cost to the United States of its war in Iraq. A helpful website *http://www.costofwar.com* will update you at any time.

It was just over 160 billion $US last time I looked (figures the website claims are based on Congressional appropriations) It points out that this sum is enough to fully fund a global anti-hunger campaign for 6 years, or a worldwide AIDS plan for 16 years, or immunise every child in the world for 53 years.

There is no doubt there's money to be spent. It's simply a matter of what our fearless leaders want to spend it on. Obviously, spending it on 'Life the Universe and Everything' is not high on the list of priorities.

We have made the most miraculous advances in technology in the last hundred years. We fly as frequently as if we were catching buses and use high speed cable internet to resolve disagreements at the dinner table. We 'zap' our processed foods in microwave ovens and send pictures of ourselves on videophones. Yet we seem to have advanced very little, philosophically. Some might argue that we have regressed. I made a program about Ageing some years ago, and in the course of filming, spoke to a lot of people in their eighties, nineties and one delightful woman of 105. What many of them noted to me was that these days, everyone was obsessed about money, worried about money, thought money was the only important thing. Needless to say, it was an observation made with some regret.

We have an obsession with wealth creation. We have come to believe that it is what we have all been put on earth to achieve. When the greatest minds of the twenty-third century, or the twenty-fifth, look back on us, will they praise us for our remarkable ability to create wealth by developing five hundred different models of mobile phone or damn us for our simplistic belief that as long as we have 'a beautiful set of numbers' things will be right with the world.

As Einstein said: 'We act as though comfort and luxury were the chief requirements of life, when all we need to make us happy is something to be enthusiastic about.'

It's a strange thing that we have all grown to equate everything to money as I have done just a few minutes ago in discussing the cost of the Superconducting Supercollider. We all know that the cost of the Iraq war is much more than the dollar number anyone can come up with. More than 15 hundred allied troops and possibly ten times that number of Iraqis have died and many many more have been injured. Their families will live with the consequences of the war for the rest of their lives. Some of their children will carry the trauma to the next generation. Why do we feel we must put human costs into dollars?

It is the influence and power of science which has contributed to people wanting to quantify everything. If you can measure something, you can discuss it dispassionately and objectively. It's an attempt to remove emotion and bias from decision-making. Now, if you put a price on everything, you can start to compare dissimilar things. Like the cost of the war in Iraq and a World Aids prevention campaign.

The problem is we haven't been very diligent with the calculations. Especially when it comes to things that are difficult to quantify like the price the environment is paying to make some of us rich. If polluters were presented with an accurate clean-up bill, their fabulous profits may well be turned into dramatic losses. The trouble has been that we haven't been able to work such complicated things out. But with ever-burgeoning computer power and increasing understanding of complex systems, we will in future be able to make these calculations and as we do, I optimistically predict there will be increasing political pressure for these extra costs to be added to our business balance sheets.

Of course not everything can be quantified in this way. Some things simply have value to our souls.

Einstein is quoted by famous physicist, Max Born as saying 'It would be possible to describe everything scientifically, but it would make no sense; it would be without meaning, as if you described a Beethoven symphony as a variation of wave pressure.' (Born 1966). (As an aside ... what famous Australian is related to Max Born? Answer: Olivia Newton-John. Her mother was Max Born's daughter.)

PSYCHOPATHS

I've just been reading a book written by John Clarke. Not the Comedian but a Sydney Psychologist.

The book's called 'Working with Monsters' (Clarke 2005) and it's about workplace psychopaths whom Clarke claims are much more numerous than the serial murder type who end up in the papers and on the television news. In fact he says that one in a hundred people might fall into this category. (Incidentally, twice as many of them are men as women.) The definition of such a person (sometimes also called a 'sociopath') is that they have no conscience or remorse, no empathy for other people whom they love to dominate. They are prepared to go to almost any lengths to get what they want, and their goals are short-term. They don't have the same reservations as most people about the risk of being caught for doing the wrong thing. These are not people any of us would like to work alongside.

Now think about how the workplace has changed in the last few decades. There is much less security, we work longer hours, there's less loyalty expressed between employer and employee. The only thing that matters is to cut costs and increase efficiency. Has this environment provided fertile ground for the workplace psychopath?

Many employers, employ people for nine months of the year. They lay them off for three months over Christmas so they don't become permanent employees with all the benefits to the employee (and costs to the employer) that would entail. If companies and large organisations only care about profits or cost-cutting and not the welfare of their workforce, they create a culture where psychopaths, who are prepared to get a result without worrying about detrimental impacts on employees, can prosper. In fact, one of the studies Clarke cites in the book is the different ways three groups of people respond to a test. The three groups were: normal (non criminal, non psychopaths), criminal (non psychopaths) and diagnosed psychopaths.

There were three ways to train the subjects to do something.
1. physical punishment (an electric shock) — you have to ask yourself about the psychopathic tendencies of the psychologists, but that's another matter
2. social punishment (the tester saying 'wrong')
3. loss of money (taking money away from the subject that they had earned for correct answers they'd given previously).

The interesting result of these tests was that normal people could learn from all three forms of punishment - the physical, social and monetary.

The criminals who weren't psychopaths could learn from two forms of punishment the physical and the monetary but didn't seem to respond much to the social punishment; being told that what they were doing was wrong.

And the psychopaths learned only one way. The only thing that taught them a lesson was taking the money away. Even the physical pain of an electric shock didn't help them to change their ways.

Think about that. Now imagine we take that lesson and apply it to society rather than individuals. What I'm asking is how does modern western society 'learn' to do things or not do them? Do we respond to 'social' punishment when we know something is 'wrong'? Have we responded to the AIDS epidemic in Africa where more than 25 million people are now infected, where 3.1 million new infections occurred in

2004 and there were 2.3 million deaths in the last year? (Note that the new infections outnumber the deaths rather ominously indicating that things are only going to get worse.) Have we recognised that this is intolerable and we must act? Have we responded to the growing gap between rich and poor between and within countries and tried to stop it?

I hope you'll allow me a digression here to explore that gap.

These figures are for the United States (from their Census Bureau) and when it comes to income distribution, it seems that 1968 was the 'Annus Mirabilis'. This is the year when the gap between rich and poor was smallest. The bottom 20% of wage-earners in 1967 earned $7,419 per annum and the top 20% earned $81,883. But by 2002, thirty five years later (more than a generation) the numbers for the bottom 20% have not increased much at all. The bottom 20% of families are earning $9,990 while the top 20% are earning $143,743. What that means is that poor family incomes have increased by just under 35% in the last thirty five years. But rich families have increased their income by more than twice that: They are better off by more than 75%.

Now in researching this subject I came across the arcane world of income inequality calculation.

One paper talked about the 'gaussian kernel density function for the worldwide distribution of income.'

There are various different systems for calculating income inequality. There's the mean logarithmic deviation, the Theil index, the variance of log-income, two Atkinsons indexes, the coefficient of variation and the Gini coefficient. (I'm not making this up.) The most popular seems to be the Gini coefficient which can be written as:

$$G = \left| \sum_{k=0}^{k=n-1} (X_{k+1} - X_k)(Y_{k+1} + Y_k) \right|$$

where G = the Gini coefficient; X = the cumulated proportion of the population variable and Y = the cumulated proportion of the income variable.

However complicated this may look to the non-statisticians among us, the concept is fairly simple.

When the Gini ratio is low this means there's less of a difference between the rich and the poor. When the Gini ratio is high, it means there's more of a gap between rich and poor. A graph of this Gini ratio for the United States shows that inequality has been on the rise since the late 1960's. But according to Jack Rasmus, who is chair of the San Francisco Writers' Union (Rasmus 2005), the shift has been dramatically with the very richest in society. He claims that 90% of America's households have had a 15% drop in the share of America's income since the 1970's, and that only a few percent have had dramatic increases. The top-earning one percent of America's households, according to Rasmus have had a 47% increase in their share.

Here in Australia, (Leigh 2004) this ANU study shows the Gini index rising more sharply here since the early 1990's than in the USA and the UK. That means the gap between rich and poor in the last decade has widened more rapidly in Australia than it has in the US and UK.

The argument about the gap between rich and poor countries is a little more complex. The figures are skewed rather dramatically by the massive industrial revolution underway in China. The huge economic changes taking place in China in the last decade or so have turned this trend around worldwide. I was surprised to learn that on 2003 figures (*http://www.infoplease.com*), the GDP per capita in China is $5,000 US. And that's a population of well over 1.3 billion people. The economy is now worth $6.5 trillion US, which makes it twice as large as Japan's economy and more than half the size of the United States'. So the next decade will be very interesting.

The Chinese curse 'may you live in interesting times' could be very apt, although the phrase has Chinese scholars puzzled. They believe the source to be American.

Certainly, US President, John F. Kennedy used it in a speech in Cape Town in 1966. The Chinese think it might be a miss-translation of the Chinese proverb 'It's better to be a dog in a peaceful time that be a man in a chaotic period.' But that doesn't have the same ring does it?

But back to rich and poor countries. While China is so big that what's happening there can skew the figures, I note that the poorest countries in the world, have a per capita Gross Domestic Product of only US$500 to $700 a year. These countries are East Timor, Somalia, Sierra Leone, Tanzania, Malawi, Afghanistan and Ethiopia. The richest countries such as the USA, Norway, Switzerland, Denmark, Canada and Australia have per capita GDP of around $30,000 US. That's 40 to 60 times the income per person of the poorest countries. And things are set to get worse. The inflation rates of the poor countries are on average five times that of the rich ones. And that means money in poor countries won't go as far next year as it did this year.

Now that was a rather long digression, I'll admit. The question I asked before was: Have we responded to the growing gap between rich and poor and tried to stop it? I think the answer is a resounding NO. We do not seem to be able to respond to something just because someone reminds us that it is wrong.

What about physical punishment? (You'll recall that in the tests there were social, physical and monetary punishments) Let's think about the sorts of physical punishment we are enduring?

One to two billion people on earth are now malnourished — more than ever in history just as obesity is becoming a major health problem in the West. We are salting up our land and using up our water without thought of where it will come from in the future. We are extinguishing species before they are discovered (choose a number here between 500 total and 27,000 a year) and chopping down 20 million hectares of forests.

And then there's global warming — the most powerful country on earth doesn't think it's worth signing the Kyoto Agreement in spite of the now alarming news that the global warming we have so far experienced of 0.6 of a degree may have been seriously masked by the effect of 'global dimming' caused by the unhealthy particulates traditionally produced with the burning of fossil fuels. The theory is that as we clean up our use of fossil fuels and reduce particulates, a much more dramatic warming will occur bringing with it extreme and unpredictable weather patterns which will be very unpleasant to live with.

And just last week came a massive report card. Called the 'Millennium Ecosystem Assessment' it was commissioned by the United Nations in 2000 to look at the future of the world's natural assets and human well-being. This is not the ramblings of a band of lefty tree huggers. It involved the work of 1,360 experts from 95 countries and has been scrutinized by governments and independent scientists. It's basically an audit of our natural assets and what's happened to them in the last fifty years or so. Here's one of the sober statements from the board.

'At the heart of this assessment is a stark warning. Human activity is putting such strain on the natural functions of Earth that the ability of the planet's ecosystems to sustain future generations can no longer be taken for granted.'

Here are some of the numbers.

§ Water withdrawals from rivers and lakes for irrigation, household and industrial use doubled in the last 40 years.

§ In some regions such as the Middle East and North Africa, humans use 120% of renewable water supplies (due to the reliance on groundwater that is not recharged).

§ More land was converted to cropland since 1945 than in the eighteenth and nineteenth centuries combined, and now approximately one quarter (24%) of Earth's terrestrial surface has been transformed to cultivated systems.

§ Since 1980 approximately 35% of mangroves have been lost, while 20% of the world's coral reefs have been destroyed and a further 20% badly degraded or destroyed.

§ At least one quarter of marine fish stocks are overharvested.

§ In some areas, the total weight of fish available to be captured is less than a hundredth of that caught before the onset of industrial fishing.

The authors include Lord Robert May, (a recipient of the Royal Society of New South Wales' Edgeworth David Medal) formerly a professor of Physics at the University of Sydney who went on to work on chaos theory and ecosystems in the Department of Zoology at the University of Oxford, then became Chief Scientist in Britain and is now President of the Royal Society of London.

Here's what the authors say.

'Although evidence remains incomplete, there is enough for the experts to warn that the ongoing degradation ... is increasing the likelihood of potentially abrupt changes that will seriously affects human well-being. This includes the emergence of new diseases, sudden changes in water quality, creation of "dead zones" along the coasts, the collapse of fisheries, and shifts in regional climate.' (Millenium 2005).

The future sounds pretty painful to me unless we can turn these trends around. But so far, we don't seem to be moved by the threat of this kind of physical punishment.

That just leaves us with the money. It is the one thing which seems to sway decisions in our modern world. Decisions are regularly made in response to the threat of the money being taken away.

Now back to our psychopaths. Apart from not having a conscience, psychopaths also have an overly grand sense of themselves and their own abilities and their most well known characteristic is that they get pleasure from the pain and suffering they cause.

So, if I apply the criteria of the psychologists to modern society, I'm afraid this amateur psychologist, must diagnose western society to be psychopathic. Where are we getting pleasure from pain? On just about every reality television program you might care to watch. They are all based on ritual humiliation. And we don't seem to be able to get enough of them.

So how does a whole society get psychiatric help? That's a hard one. Call me incurably optimistic if you like, but I'm sure it's possible. One of modern society's most powerful tools is science. But we must direct this powerful tool at the appropriate tasks. That is our challenge. Science needs to be done to solve the important problems we face. If we simply harness it for profit creation we are not using it properly. It's like using your only horse to run in the Melbourne cup, instead of getting it to pull a plough. It might have a chance of making a lot of money, but you could starve to death in the meantime.

So how are we using science in Australia? Let's take a look at trends in where the money's going. These figures come from the Federal Government's Department of Education, Science and Training, 2004. First the good news.

We are spending a larger percentage of our Gross Domestic Product on research than we used to. This is good. In 1978-9 it was 0.93% of GDP and in 2002–3 it was 1.62%. That's a 74% increase.

But here's the bad news. It's less than most other countries are spending. Australia is near the bottom on 1.62% of Gross Domestic Product. Sweden is at the top with 4.27, the US is on 2.67, OECD average is 2.26 and the EU15[1] is on 1.93. So we are not matching other advanced countries in putting money into scientific research. (By a back of the envelope calculation, Australians together would need to spend another five and a half billion dollars on research to reach the per-capita level of the United States)

[1]The EU15 is the existing 15 European Union countries

Now let's look at the breakdown of where the money comes from and where it goes. If we look at who's doing the research between 1978/9 to 2002/3 we find that overall higher education is pretty constant over the period at about 30% (it's dropped nearly 3% as a percentage but it's higher than it was in the early 90's). The amount of research being done by the government sector, that's the CSIRO and other dedicated government research bodies, has had a remarkable change from 44% in 1978/9 to 20.3% in 2002/3. That means that less than half the research, as a percentage of GDP, is being performed by the government research bodies compared with the late 70's.

The figures for the source of funds have changed correspondingly. Government has contributed a diminishing proportion of R&D funding, the percentage falling from 76.5% in 1978/79 to 44.4% in 2002/3. Business investment has increased over the same period from 20.6% to 46.4%

I was a little curious whether these figures of business spending on R&D included the tax concessions given to business by government for undertaking the research. These concessions are 125% for research undertaken for under three years and sometimes as high as 175% for research continuing over three years. According to my telephone conversation with the compiler of the statistics (pers. com. Shi 2005) these concessions are not included as they are not direct expenditure but government income foregone. In fact the figure which doesn't make it into the above data is 375 million dollars for the 02/03 tax year. But even that is only the 'extra' 25% in the 125% tax deduction. So the total amount in tax deductions is five times this amount which is about 1.8 billion dollars. I mention this because if these numbers were taken into account, the data would show a substantially greater amount of government money going into funding research which is being carried out by business. In most countries, the tax rebate is 100% and not 125%, yet even with this incentive, Australian business is not investing in scientific research as much as business in other countries. The grand total for both business and government expenditure on research in 2002/3 was twelve and a quarter billion dollars which is just slightly less than Australians spend on gambling each year.

What all this means is that taxpayers are paying for more of the research than they know, but are not able to dictate or even lobby or protest about where the money's going. And this is a phenomenon that is taking place around the world. We are using the powerful tool of science to create wealth. And there's nothing wrong with that as long as it's not at the expense of more important missions. Unfortunately, I'm afraid it may well be.

Of the twelve and a quarter billion dollars we put into research 63% was aimed at economic development, compared to about 6 and a half percent each for non-oriented research (the purple wedge) and the environment (in green).

When you break down the economic development portion (a sum of nearly eight billion dollars) manufacturing took the lion's share of 38% and if you add in mineral resources, energy resources and energy supply research you're well over 50%.

Finally, while Australia's average expenditure on R&D is 1.62%, research data shows that New South Wales is lagging sadly behind. Only 1.41% of this state's GDP is being spent on research, well below South Australia, Tasmania and Victoria. (ACT is so high because it has more than its fair share of CSIRO laboratories and the ANU Institute of Advanced Studies.) This alone should stir us in the Royal Society of NSW to lobby the State Government for increased funding for scientific research in NSW and of course for funding for the Royal Society as ours is the only state Royal Society *not* receiving any government support.

THE ROYAL SOCIETY

I sometimes say that I would like the Royal Society of New South Wales to become so prestigious that it no longer wants me as a member (with apologies to Groucho Marx). But I have

been a member for a number of years and I'd like to take a short time to tell you about developments at the Society in recent times.

In July 2004 The Royal Society of New South Wales moved office. This has only happened a handful of times in the last hundred years. We are now well settled at 121 Darlington Rd, Darlington in a Victorian terrace owned by the University of Sydney. We are indebted to Vice Chancellor, Gavin Brown for his support in providing us with a new home. The University also regards us as part of the University Community, which means we can use its venues without being charged normal commercial rates.

Our lectures are now being attended by a respectable number of people and the numbers are on the increase. We are still not as successful in Sydney at attracting an audience as we are in the Southern Highlands branch of the Royal Society of New South Wales, but Sydney's gaining. Increasing numbers to lectures is a great achievement in Sydney where working hours are long and travel times to and from work are growing all the time. I have also noticed that members and friends are talking animatedly before and after lectures and more are enjoying dinner with the speaker later in the evening.

On December 4$^{\text{th}}$ 2004, all the State Royal Societies met for what we believe is the very first time. It was an historic occasion and came about with the encouragement of the Governor-General, Major General Michael Jeffery, who hosted a function for the attendees at Admiralty House in Kirribilli. It was inspiring and interesting to see the diversity of activities being undertaken by the different societies. Delegates described scientific expeditions, environmental conferences and a wide range of publications. We heard of member excursions to places of a scientific interest and contributions to the science policy debate. One of the matters discussed was whether we should resurrect the Royal Society of Australia, granted royal approval in 1931, as an umbrella organisation to help the Royal Societies on national matters.

There is much ahead to do. We need to attract funding to support our office, as the generous support of our benefactor, Clive Wilmot will come to an end at the end of this year. We need to attract a grant to work through the more than thirty boxes held by the State Library of NSW and to better document the history of the Society. But most importantly, we need to make sure that the Royal Society of New South Wales makes a substantial contribution to the intellectual life of NSW.

TIME

Now briefly back to time. Despite the promises of the 70's that we would have more leisure in the future, the truth is we don't. In fact we have so little time, working people can't do voluntary work, look after sick relatives, or get organised politically. We sleep shorter hours than previous generations and go around permanently sleep deprived in spite of warnings that this impairs our performance more than alcohol. Mobile phones and home computers mean we are 'on line' all the time, available at any hour. We fill our lives with chores and ephemera and impose the same regime on our children. Their time is so structured they need permission to sit and dream. I don't know what Einstein would have made of it. Not much I think. But here's his simple explanation of relativity.

'When a man sits with a pretty girl for an hour, it seems like a minute. But let him sit on a hot stove for a minute and it's longer than any hour. That's relativity.'

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Ideal Energy Source by Mark Oliphant's Beam Fusion

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Abstract: The 70-year anniversary of the first nuclear fusion reaction of hydrogen isotopes by Oliphant, Harteck and Rutherford is an opportunity to realize how beam fusion is the path for clean, safe, unlimited and low-cost energy production, including magnetic confinement fusion and inertial fusion energy (IFE). The measurement of unpredicted low energy fusion reactions compared with the usual nuclear reactions was a significant discovery. It is intriguing that Oliphant's basic concept from 1937 for igniting controlled fusion reactions for generating energy by beams has a comeback even for magnetic confinement plasma, after this beam fusion concept was revealed by basically non-linear processes of the well-known alternative of inertial confinement fusion using laser or particle beams. After reviewing both directions some results are reported as to how experiments with skin layer interaction and avoiding relativistic self-focussing of clean PW-ps laser pulses for IFE may possibly lead to a simplified fusion reactor scheme without the need of special compression of solid deuterium-tritium fuel. It may be that energy can be produced at a five times lower cost than from any present energy source.

Keywords: nuclear fusion, energy, plasma, laser, particle beam, Oliphant

INTRODUCTION

The very first nuclear fusion reaction (Oliphant et al. 1934) was achieved using a 100 keV gas discharge. Heavy water for the deuterium was produced by Paul Harteck and analysis of the cloud chamber pictures by Lord Rutherford was especially difficult (even for the grandmaster Rutherford, the founder of nuclear physics), since the unknown super-heavy hydrogen isotope tritium $T = {}^3H$ appeared as well as the light helium isotope ${}^3He$, protons $p = {}^1H$, neutrons n and the usual helium isotope ${}^4He$.

$$
\begin{aligned}
D + D &= T + {}^1H + 4.03 \text{ MeV } (50\%) && (1a)\\
& {}^3He + n + 3.27 \text{ MeV } (50\%) && (1b)\\
D + {}^3He &= {}^4He + {}^1H + 18.3 \text{ MeV} && (2a)\\
T + D &= {}^4He + n + 17.6 \text{ MeV} && (2b)
\end{aligned}
$$

The tritium reaction (2b) has an extraordinary large reaction cross section and is the main subject of the discussion below, although the neutron-lean reaction (2b) is now of special interest in view of the possibility of harvesting ${}^3He$ as fusion fuel from the surface of the Moon.

Reactions of the very light elements at beam energies around 10 keV was a significant discovery since the usual beam energy has to be considerably above 1 million volts in order to move the nuclei against electrical Coulombic repulsion to distances of their diameters (of the order of femtometers, $1\,\text{fm} = 10^{-13}$cm). The tools for these experiments were the multi-million-volt accelerators. Cockroft was sufficiently adventurous (with little knowledge of systems using many millions of volts) to look to see what happens when only 100 to 200 keV were used; light nuclei such as boron did react with protons (Cockroft et al. 1933). It was then that Oliphant's gas discharge technique was used to produce the necessary high currents to get more precise results, such as the correct value of the proton-boron reaction (Oliphant and Rutherford, 1933), and this was the prelude to the discovery (Oliphant et al. 1934) of the famous fusion reactions (1) to (2b). It has to be realized that these 'hot fusion' reactions at 10 keV impact energy (corresponding to temperatures of 10^8 °C) happen at distances about hundred times larger than the femtometer distances of the usual nuclear reactions. This cannot be explained by a Gamov factor. Measurements of the fusion reaction cross sections involved are now highly accurate, but there was no theory for explaining them, apart from numerical fitting (Clark et al. 1979). It was not before Li et al. (2000) that a reasonable theory was devel-

oped using a Schrödinger potential. The cross sections could be reproduced using the two obvious parameters, the resonance energy and the resonance width (Li et al. 2004).

The following reflects on some initial experiments of Oliphant (1972) in 1937, especially in the direction of fusion reactions using beams, and how these may be considered some seventy years after the first fusion reaction (Oliphant et al. 1934). Developments went first against the initial concept of beam fusion in favour of avoiding any beams; these moved in the direction of magnetic confinement fusion. The subsequent text is an analysis how this aspect has changed back towards the initial view of Oliphant for beam fusion. This is not only a question of inertial fusion energy (IFE) without magnetic fields, as known from laser- or particle beam-driven fusion reactions. Even the initial magnetic fusion concept has developed into a beam fusion scheme during recent years.

DISCUSSION

The Spitzer Criterion and the Impossibility of Beam Fusion

First attempts to develop the reaction into an energy source were made by Oliphant (1937) and a continuation of a controlled reaction for power production was considered about 1950. Studies of fusion reactions for energy production were a continuation of the work of 1937 carried out under the leadership of Nobel Laureate E.O. Lawrence, together with Oliphant and other important pioneers. The aim was just to produce extremely intense deuterium or D-T beams from gas discharges or otherwise with about 100 keV energy to irradiate targets containing D or D-T. These attempts were emphatically rejected by Spitzer (1957), who argued that such beam experiments do result in fusion reactions as measured (Oliphant et al. 1934), but that it was absolutely impossible to produce more energy by fusion than that used to generate the beams. Lawrence and the others simply argued that one just had to apply higher and higher beam powers, but this was made ridiculous by Spitzer's suggestion that the fusion cross section is more than 300 times smaller for the incident 100 MeV nuclei than their interaction with the electrons in the bombarded target. The ion energy is used mostly to heat the electrons in the target, but never permits an exothermal fusion reaction.

Spitzer's argument was mathematically simple, and physically and logically fully clear. It led to the decision that, instead of bombarding a cold target, one had to heat the all reacting particles — as in the sun — up to the plasma state at a temperature of dozens of million degrees, so that ions do not lose their energy by collision with electrons, and the desired fusion reactions can take place. The problem was then how to confine the plasma by magnetic fields and to find conditions where the loss of radiation energy and confinement mechanisms for the hot plasma are more than compensated for by the generation of fusion energy.

Following Spitzer's argument, the handling of the fusion plasma with magnetic confinement is at a stage that a test reactor (ITER) is to be built by 2015 and may lead to a power station with 4 GW fusion energy output by 2040 (Hoang et al. 2004). This all is based on expensive research during the last 50 years, with the highest fusion gain of 16 MW being reached in the Joint European Torus (JET) experiment at Culham, England. However, this was mainly a *beam fusion experiment* (Hora et al. 1998; Hora 1987), supporting Spitzer's argument that the irradiated target had no problems with low temperature electrons. In a wider sense, this is a sophisticated *verification of Oliphant's beam fusion* idea by way of a 'Spitzer option' for fusion energy. It should be emphasised that the concept of neutral beam irradiation was introduced by Harold Furth, based on his 'idea of exploiting fusion reactions that arise from injected energetic ions' (Fisch et al. 2004). It is noted in passing that Furth was the nephew of Paul Harteck the co-discoverer of the first fusion reactions (Oliphant et al. 1934).

There is another reason why Spitzer's arguments are invalid and this concerns linear versus

non-linear physics. In non-linear physics, results from linear physics can be completely different, as experienced in other physics examples (Hora 2000). Non-linear physics does indeed permit beam fusion, in contrast to the Spitzer argument, as initiated by Oliphant (1937), especially since the invention of the laser opened the door to the application of non-linear physics for fusion energy (Tanka et al. 2001). This perhaps may be considered as a further confirmation of the comeback of beam fusion envisaged by Oliphant and is discussed below as the 'Non-Spitzer' option.

The Spitzer Option for Fusion Energy

Magnetic confinement of a plasma is mostly focussed on toroidal geometries. Spitzer's initial magnetic stellarator configuration, built at comparably high costs, was simplified into a toroidal configuration and the early problems of generating a very low current stellarator plasma were overcome by Grieger et al. (1981), who produced fusion neutrons with an 800 eV deuterium plasma. The diffusion of the plasma against the confining magnetic field due to collisions was about 20 times faster than classical collisions predicted. This could be explained directly as a quantum correction to the collisions for anomalous resistivity, since the factor of 20 did immediately fit the change at a temperature above 37 eV by a linear temperature factor (Hora 1981). The experiment had the advantage of transparent measurements as can be seen from the abovementioned factor of 20. There is a modification of the classical electron ion collision frequency, ν_{class}, which is valid only below the temperature $\text{T}^* = \text{z}^2(4/3)\text{mc}^2\alpha^2 = 36.8\ \text{Z}^2$ eV (using the ion charge z), as shown by Marshak (1941) and generalized later (Hora 1981; see Hora 1991, Chap. 2.6). Above the temperature T^* the quantum mechanical value has to be taken, as in (3).

$$\nu_{\text{ei}} = \nu_{\text{class}}\ \text{T}/\text{T}^* \tag{3}$$

This is the modification of the diffusion of the plasma across the magnetic field and was confirmed by Grieger et al. (1981), who arrived at the factor 20 by the relation $800\,\text{eV}/\text{T}^*$ (= 21.7).

In contrast to this zero-current toroidal magnetic confinement stellarator, a toroidal confinement with a very high axial electric current for heating the plasma was developed as a tokamak (Hoang et al. 2004). This most advanced scheme is used in the International Toroidal Experimental Reactor (ITER) at a cost of $US10 billion, and planned to be operational in 2015. Confidence for this decision is based on recent achievements with tokamaks (Hoang et al. 2004). It is envisaged that a subsequent test power station may be finished in 2040 if no unforeseen difficulties, such as wall erosion, blistering from the walls or anomalous ion implantation, arise (Hoang et al. 2004). These time scales agree with what the Director for the very large European budget for magnetic confinement fusion research formulated in 1993 in that this development 'will need at least 50 years ... and it is not sure whether the produced energy will be of sufficiently low cost' (Maisonier 1994).

The high achievements of tokamak developments are seen (Hoang et al. 2004) from the fact that its performance doubled every 1.8 years, compared with that of transistor and chip technology every 2 years, and that of the particle accelerator every 3 years. Operating the tokamak completely as a magnetic confinement device by inductive heating has not succeeded yet for more than about one second. The operation of advanced tokamaks with superconducting coils, with external heating by neutral beams and RF electromagnetic irradiation, is possible over 1000 seconds in the Tore Supra at Cadarache, France, or with a smaller Japanese device with 100 times lower input power over three hours. The maximum neutral beam density for driving the tokamak is limited by the Langmuir-Child space charge law for ion beam generation to less than $10\,\text{mA}\,\text{cm}^{-2}$, in contrast to the measured many orders of magnitude higher ion current densities emitted from targets by laser irradiation (Laska et al. 2003; Wolowski et al. 2003).

The highest nuclear fusion gain measured by the Joint European Torus (Hoang et al. 2004; Hora et al. 1998) was 16 MW, produced by 21 MW neutral deuterium beams of 60 keV energy and by irradiation with MW RF power. The tokamak was filled with D:T = 40:60 (Hoang et al. 2004). This 66% gain, close to break-even, does not take into account the power needed to operate the tokamak. In this connection, instead of the very high power consumption of the tokamak coils, superconducting magnets could have been used at considerably lower power but with losses for cooling of magnets and limiter etc. It is important to note that operation of JET without beam injection as a purely magnetic confinement device results in very much lower fusion reaction gains.

Returning to the initial question about Oliphant's view on beam fusion, we see that the highest fusion gain of the JET is in a clear (neutral) beam fusion experiment, irradiating a target which fulfills the linear physics conditions of the Spitzer option, but using a sophisticated high temperature tokamak plasma instead of a solid state target. In this case, as postulated by Spitzer, collisions between the irradiated ion beam and the target electrons do not consume much of the main ion beam energy (Hora et al. 1998).

A higher gain (above break-even) could have been expected if the number of ion beam injectors had been multiplied. Further improvements may be expected if the detection of the inward particle flux as observed at the Tore Supra could be analysed as being caused by E×B-net plasma rotation (Goldsworthy et al. 1987; Hora 1991, p. 171) or reduced thermal conduction due to anomalous resistivity (Hora 1981; Hora 1991, p. 50). In view of the problems of wall erosion in tokamaks, mainly due to disruption instability, one may consider a neutral beam fusion device where instead of the tokamak target, a stellarator is used and disruptions are excluded (Wobig 2002).

Non-Spitzer Option for Fusion Energy

We refer now to beam fusion where nonlinearities overcome the Spitzer criteria. The idea was obvious in 1960 after the discovery of the fact that lasers can be used for producing extremely high energy densities within very short times in very small volumes, as needed for controlled ignition of nuclear fusion reactions. The pioneers of large-scale fusion reactions (Teller 2001; Nuckolls 1992; Sakharov 1982) immediately devoted attention to this concept. Particle beam fusion — fully excluded under aspects of the Spitzer criteria — was also revoked in view of non-linearity. Spitzer's argument keeps its full validity as long as the beam-irradiated target remains solid. However, if the beam intensity creates plasma with very complex hydrodynamic developments, dynamics of pressure profiles and radiation effects, exothermic energy production can be expected by laser driven fusion or from igniting self-sustained fusion reaction fronts by an intense electron beam (Yonas 1978), or by light or heavy ion beams working through solid fusion fuel. The laser fusion concept has been well-developed since, but new developments with picosecond laser pulses may allow us to return to several earlier arguments for ion beam fusion.

When estimating the necessary conditions for igniting a self-sustained fusion detonation front in uncompressed solid DT by impact of a DT ion beam, a minimum ion beam density of

$$j_{min} = 10^{10}\ \mathrm{A\,cm^{-2}} \tag{4}$$

was given (Brueckner et al. 1974); this may be too pessimistic and a lower value may be possible. A further condition is that the energy density of the hot detonation front should be at least that given in (5) (Bobin 1972).

$$\mathrm{ED} = 4 \times 10^{8}\ \mathrm{J\,cm^{-2}} \tag{5}$$

This value may be decreased by a factor of 20 or more when interpenetration processes are included (Hora 1983). These conditions are far beyond available electron or ion beam technologies for igniting solid state DT. With the laser, however, these conditions have been achieved experimentally, as will be explained in the following section.

A further improvement for igniting beam-irradiated DT fuel is its compression above the solid density. This can be achieved with the irradiating laser or particle beam itself, by producing an ablation of fuel from the irradiated surface, which results in a compression of the interior by recoil. With spherical geometry the compressed core of maximum density n_o and volume V_{Os} (s denotes that this is the volume of the uncompressed solid fuel with a density n_s) receives an energy E_o which may be assumed to be uniformly spread over the core volume. The adiabatic compression and expansion of the core, confined only by its inertia (inertial confinement fusion, ICF), following the self-similarity model (Hora 1991, Sect. 5), results in a DT fusion core gain G at an optimum temperature $T_{opt} = 17\,\mathrm{keV}$ at maximum compression

$$G = (E_O/E_{BE})^{1/3}(n_O/n_s)^{2/3} \qquad (6)$$

(Hora 1991; Hora et al. 1998; identical to the ρR value), where E_{EB} is the break-even energy (6.3 MJ for DT). This result, based on numerical values of the fusion cross sections, shows immediately how a compression to 1000 times the solid density requires a million times less core energy for reaching the same gain.

Formula (6) does not include fuel depletion, partial reabsorption of lost bremsstrahlung and the gain of temperature by the fusion products before leaving the reacting plasma (self heat). When including this (Hora et al. 1998), the result in Figure 1 is very close to the value of (6), where for constant core volume a standard isochor touches the optimised fusion gain plots at T_{opt} if the gain is less than 8.

For higher gains, the isochors are deformed, showing volume ignition (Hora et al. 1978) with increased gains and lower optimum temperatures (bending of the vertical dashed lines to the left). It is remarkable that the measured highest gains at direct drive laser fusion spheres fully agree with these isentropic self-similarity computations (Fig. 1), indeed below ignition as simple volume fusion burn or quenching.

In contrast to this volume burn with rather low gains, the scheme of spark ignition was introduced at end of the 1960s (Nuckolls 1992) to produce very much higher gains than by simple burn, before volume ignition was discovered (Hora et al. 1978; Hora et al. 1998). This could reach nearly the same high gains in a much more natural way of adiabatic compression. The spark ignition is rather complicated. It tries to schedule the compression in a very sophisticated way, especially when, instead of direct laser drive, indirect drive by hohlraum X-radiation is used. The laser irradiates the inner walls of a capsule to convert the radiation into X-rays, which then produce a very symmetric compression of the fuel pellet within the capsule. The aim is that the compressed pellet has a low density, high temperature central spark plasma surrounded isobarically by a very high density, low temperature outer part. At the interface, the hot plasma ignites a spherical fusion detonation wave in the cold outer plasma with similar conditions as given by (4) and (5), but with higher densities.

In summary, the highest laser fusion gains by spherical irradiation were 2×10^{14} DT neutrons from a 35 kJ neodymium glass laser pulse, unexpectedly following the exact adiabatic volume compression (Hora et al. 1998; Fig. 1), while the best gains from hohlraums were about 1000 times lower. If one assumes that only 5% of the 35 kJ energy went into compressed cores (95% to ablation because of bad hydrodynamic efficiency), the fusion gain is then 31%.

For better studying these mechanisms with both the fusion energy source and large scale fusion reactions in mind, glass laser facilities for producing pulses of a few MJ energy with about nanosecond duration are being built, the NIF in Livermore, California and the LMJ in Bordeaux, France (Tarter 2002; Pellat 2002). The

aim is to demonstrate ignition with a modest total fusion gain not much above 10, by about 2010.

One of the problems experienced by the experiments was too low heating of the laser-compressed plasma. Azechi et al. (1991) succeeded to laser-compress polyethylene to 2000 times the solid density thanks to Kato's laser beam smoothing with random phase plates where, however, the maximum temperature of about 300 eV was unexpectedly low. For very large scale laser fusion using few MJ laser pulses including smoothing for working with long wave lengths, this should not be too problematic if volume ignition is used for direct drive and not spark ignition. It has been calculated by Hora et al. (2003) that by doubling the compression density, volume ignition will reach the range where the bremsstrahlung re-absorption results in ignition temperatures of only a few hundred eV. This would be sufficient for a one step laser fusion reactor based on robust adiabatic volume compression as was successful with the hitherto highest laser fusion gains, but avoiding the problems of spark ignition. This would at least be a conservative solution for laser fusion based on well-established technology (Hora et al. 2003). Broad research is aimed at spark ignition (Lindl 1994) where the fusion efficiency may be two times higher than with the volume ignition concept (Hora et al. 1998), but where the problems with compression symmetry and instabilities are much more difficult.

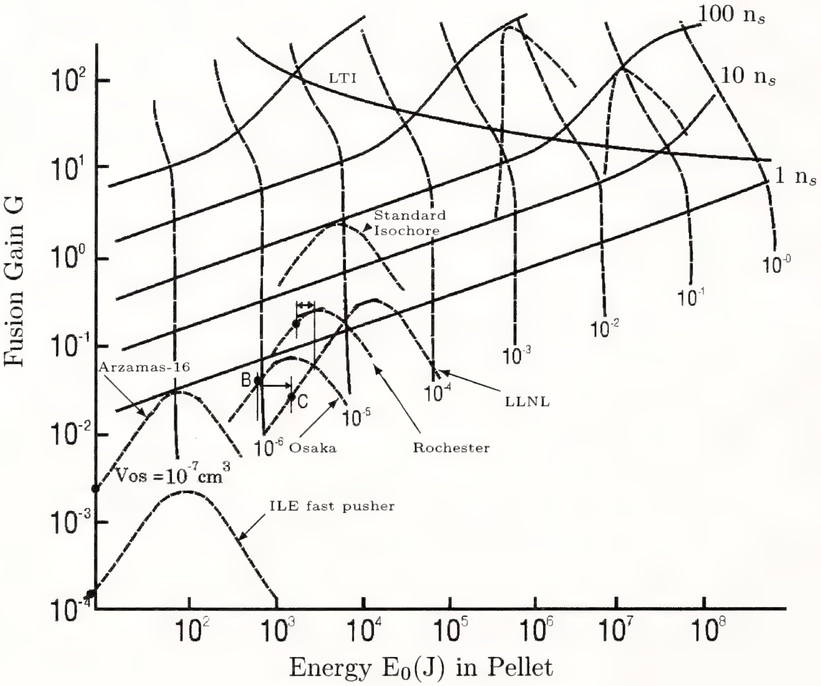

Figure 1. Optimised core fusion gains G (full lines) for the three-dimensional self-similarity hydrodynamic volume compression of simple burn (G $<$ 8) (sometimes called quenching) and volume ignition for G $>$ 8 with low temperature ignition above the LTI line. The measurements points A-D agree with the isentropic volume burn model, while the earlier fast pusher, point E, with strong entropy-producing shocks does not fit.

Non-linear Laser Force Driven Beam Ignition for Inertial Fusion Energy

The scenario for laser fusion changed dramatically with Chirped Pulse Amplification, CPA, discovered by Mourou et al. (2002). This led to the generation of pulses with neodymium glass or Ti:sapphire (or iodine) lasers of pulses in the range of picoseconds or less duration and powers exceeding 2 PW. Irradiation of targets with these pulses results in numerous, not yet fully explored, relativistic effects. Very intense gammas in the 10 MeV range cause nuclear transmutations (Ledingham et al. 2002) with elimination of long lived nuclear waste (Magill et al. 2003), producing ions of more than 0.5 GeV energy (Clark et al. 2001) or intense 5 MeV proton beams (Roth et al. 2000, 2001), with the possibility of easy generation of laser spark ignition in indirectly driven fusion pellets, or electron acceleration to more than 100 MeV energy (Hora et al. 2000).

For laser fusion, after Azechi et al. (1991) had measured 2000 times solid compression but at the low temperature of 300 eV by nanosecond laser pulses, Campbell et al. (2000) proposed that an additional ps-PW pulse may heat the centre of compressed DT for spark ignition. This fast ignitor (Tabak et al. 1994) preliminarily led to the generation of nearly 10^8 fusion neutrons (Kodama et al. 2002). The study of this fast ignition (FI) scheme is now one of the broader streams in laser fusion research. There were numerous new phenomena observed that deserve much more detailed studies and may lead each to one or other modifications of the laser fusion application. More as a possible alternative example, one of these phenomena will be considered here in some details.

One of the numerous unexpected observations was that the ions emitted with very clean TW-ps laser pulses, having a suppression of any pre-pulse by a factor 10^8 (contrast ratio), resulted in drastically low energies. The emitted ions in this special case (Badziak et al. 1999) had maximum energies of 450 keV, while 22 MeV energy was expected under the usual conditions after relativistic self-focussing. A similar observation concerned low X-ray emission from targets following irradiation with comparable intense sub-ps laser pulses of similar high contrast ratio (Zhang et al. 1998). Only when a pre-pulse was introduced at least 70 ps before the main pulse was X-ray emission usual. The explanation was very straight forward; with clean pulses there was no relativistic self-focussing possible. When an earlier (70 ps) pre-pulse was used, the necessary plasma in front of the target was produced for relativistic self-focussing (Hora et al. 2001; Fig. 2), leading to very high laser intensities in the filament for high X-ray emission. The same happens for ion emission (Hora et al. 2002) when the high contrast ratio prevents relativistic self-focussing (Hora et al. 2004), resulting then in the conditions of plane wave interaction geometry within the skin depth of the plasma. Details of this evaluation led to splendid agreement between ion energies, quiver motion for X-ray emission and dielectric swelling by a factor of 3.5 (Hora et al. 2004). Some authors now call this long-known dielectric phenomenon (Hora 1991) 'amplification', in error.

The plane geometry laser field interaction with plasma for a few picoseconds duration (Fig. 3) was studied numerically with more comfortable initial plasma distributions (Hora 1991, Sect. 10.5) than in the experiment where at least the basic mechanisms could be followed up. The laser energy goes nearly collision-less by the non-linear (ponderomotive) force (Hora 1991) into the kinetic energy of a block of plasma moving against the laser light and another block moving into the plasma interior. For this plane geometry, the general non-linear force (Hora 1991, 2000) can be expressed by the electrical and magnetic amplitudes of the laser field $\mathrm{E_L}$ and $\mathrm{H_L}$ by the ponderomotive force with the plasma refractive index $\mathbf{n}$,

$$
\begin{aligned}
f_{\mathrm{NL}} &= (\mathbf{n}^2 - 1)(\partial/\partial x)(\mathrm{E_L^2}/16\pi) \\
&= -(\partial/\partial x)[(\mathrm{E_L^2} + \mathrm{H_L^2})/8\pi]
\end{aligned} \tag{7}
$$

where the second expression denotes the force density as the negative gradient of the electromagnetic energy density.

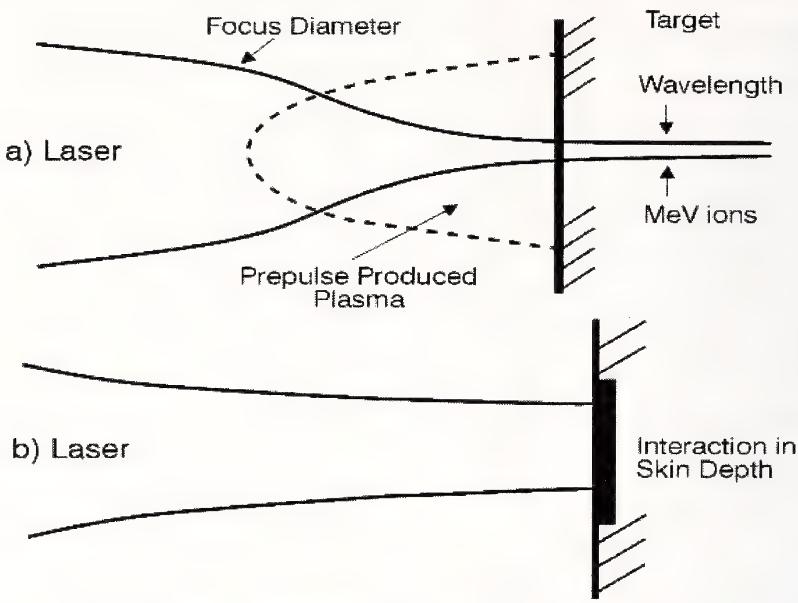

Figure 2. Scheme for demonstration of the essential different geometry of the laser-plasma interaction volumes for subsequent volume-force non-linear electron acceleration with separation by the ion charge, z. In case *a*, the pre-generated plasma before the target causes instantaneous relativistic self focussing of the laser beam to shrink to less than a wavelength in diameter with very high non-linear force acceleration due to the strong gradient of the laser field density. In case *b*, the thin plasma in front of the target permits only interaction in the skin depth with much lower ion energies but nearly ideal plasma geometry conditions.

The deuterium plasma (Fig. 3) reaches velocities up to $10^9\,\mathrm{cm\,s^{-1}}$ and more ($10^{18}\,\mathrm{W\,cm^{-2}}$ neodymium glass laser intensity), within a block of more than 15 wavelengths thickness. An advanced computation (Fig. 4) closer to the experimental conditions (Badziak et al. 1999; Hora et al. 2002) reproduced this block motion in detail, with numbers as expected from global calculations and experiments.

The DT ions in such non-linear-force driven plasma blocks have ion current densities of or above $10^{10}\,\mathrm{A\,cm^{-2}}$ (Hora 2003; Badziak et al. 2003). These fast ions are emitted within very narrow angles against and with the laser light in total contrast to the wide angles for fast ions emitted after relativistic self-focussing (Badziak et al. 2003). The property of the accelerated space charge neutral high density blocks with no strong surrounding magnetic fields underlines the basic difference to the high current density 5 MeV ions (Roth et al. 2001) from PW laser irradiation of plasmas. Here, relativistic self-focussing led to a decrease of the ion density in the focus (Hora 1975; Jones et al. 1982, Häuser et al. 1992). Magnetic fields were generated (Pukhov et al. 1996) such that the ion beams are not space charge neutralized. In this case the ions follow a free electron acceleration process with a conical emission (Hora et al. 2000) in agreement with the measurements of Umstadter et al. (1996). Since space charge neutral, highly collimated, sub-relativistic ion current densities of more than $10^{10}\,\mathrm{W\,cm^{-2}}$ (Badziak et al. 2003) can be expected for 80 keV deuterium and or tritium ion energies, the condition of (4) is fulfilled and these ions may ignite a self-sustained fusion reaction front in uncompressed solid DT if condition (5) could be fulfilled simultaneously.

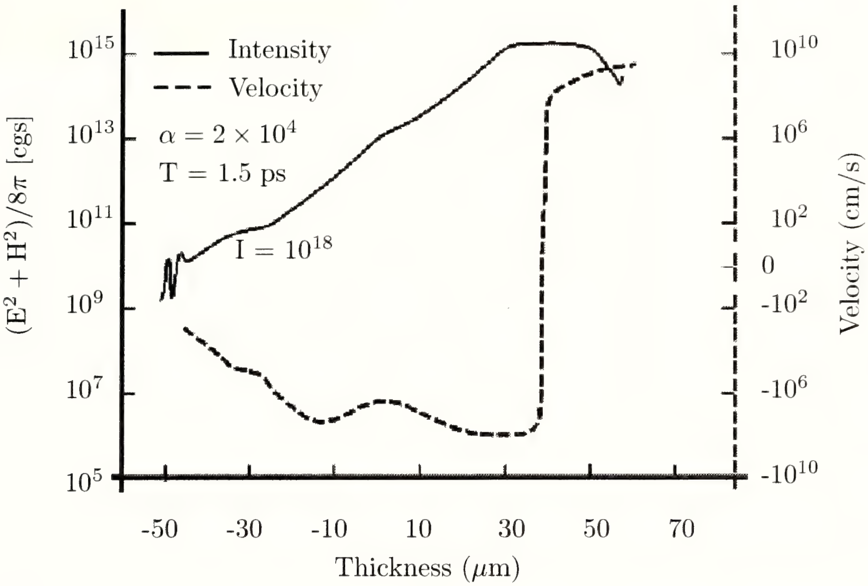

Figure 3. Generation of blocks of deuterium plasma moving against the neodymium glass laser light (positive velocities, v, to the right) and moving into the plasma interior (negative velocities) at irradiation by a 10^{18} W cm^{-2} intensity neodymium glass laser onto an initially 100 eV hot and 100 μm thick bi-Rayleigh profile with minimum internal reflection. The electromagnetic energy density $(E^2 + H^2)/8\pi$ corresponding to the intensity is shown at the same time of 1.5 ps after the beginning of constant irradiation.

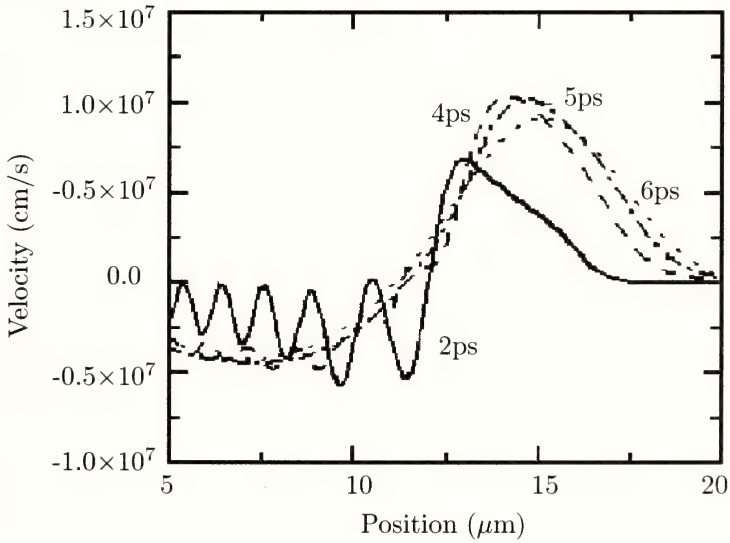

Figure 4. Ion velocity profiles at times 2, 4, 5 and 6 ps taken from genuine two fluids computations for a 3x10^{15} W cm^{-2} 4 ps rectangular laser pulse irradiating a deuterium plasma ramp of 20 μm thickness with critical density at 12 μm, confirming the generation of an ablating plasma block (negative velocity) and a compressing plasma block (positive velocity).

It is important to emphasise the fact that generation of laser accelerated blocks was measured even before the results of Badziak et al. (1999) led to the detailed conclusion of the skin layer interaction (Hora et al. 2002, 2002a; Hora 2003; Badziak et al. 2003). This was detected and analyzed from the backscattered spectra and the red or blue shift at laser irradiation of targets with 100 fs TW laser pulses (Sauerbrey 1996). Though the considerations begin with the obsolete argument of ion acoustic wave velocity, Sauerbrey (1996) acknowledges the action of the non-linear (ponderomotive) force as found in related experiments (Kalashnikov et al. 1994) and considered elsewhere (Schmutzer et al. 1977).

It is especially encouraging that the non-linear force acceleration of plasma layers to blocks moving against and with the laser light was well-recognized (Sauerbrey 1996). Experiments confirmed an acceleration in deuterium blocks of 10^{17} g, as seen also in the computations of Figure 3, where 10 μm thick deuterium blocks of 10^{21} ions cm^{-3} received an acceleration of 10^{18} g (see then discussion of how laser acceleration may reach that of the surfaces of black holes with 10^{29} g; Hora et al. 2002c). Since energy transfer to the blocks in a kind of collision-less, non-linear absorption is well known and even emerge as one of the rare analytical solutions of an integral equation (Batchelor et al. 1985), this method was proposed by Shank (1985) for measuring the pulse lengths and energy transfer of sub-picosecond laser pulses.

The remaining question concerns how the energy flux density for generating a reaction front (flame propagation) into uncompressed solid DT can be fulfilled as derived theoretically (Bobin 1971; Chu 1972) to be above the threshold of (5). Even more pessimistic higher thresholds, E*, were considered, but these may be upper bounds as long as the very extensive details for the derivation of the threshold (5) are not found to be incorrect.

It may be possible that the value from (5) is too pessimistic, as there are indications from theory as to how interpenetration of the igniting energetic ions into the cold uncompressed DT fuel may reduce E* to that in (8) (Hora 1983).

$$E_1^* = 2 \times 10^7 \mathrm{J\,cm^{-2}} \tag{8}$$

How unexplored these beam fusion conditions are may be seen from experiments (Kerns et al. 1972; Guenther 1972) where 2 MeV electrons of an estimated current density of 3 $\times$ $10^6\,\mathrm{A\,cm^{-2}}$ interacting with a CD_2 target showed a penetration of only 0.3 cm. The single electron penetration would have been more than 40 times longer. The disagreement with the Bethe-Bloch-Bohr binary collision theory for the stopping length could be clarified by applying the collective interaction process, which fully reproduces the measured 0.3 cm. The collective interaction was initially studied by Gabor (1953) and based on the independently derived theory (Ray et al. 1976) for the successful explanation (Bagge et al. 1974) of the experiments (Kerns et al. 1972, Guenther 1972). Such reduction of the collective stopping length, combined with the not yet applied anomalous plasma resistivity (Hora 1991, Sect. 2.6) and electric double layer effects with reduced thermal conductivity (Eliezer et al. 1989), points to the further decrease of the threshold (8).

Thanks to the recent results on interaction of clean TW-ps laser pulses, it was possible to show experimentally (Badziak et al. 2003) that the rather extremely high threshold j* (4), for ion beam fusion has been fulfilled (Hora et al. 2004). The skin layer interaction mechanism accelerates a plasma layer or block initially of 30 wavelength width and several vacuum wavelengths thickness with a critical density of 10^{21} electrons cm^{-3} against the laser light, whose velocity from 20 keV nucleon at 8 $\times$ $10^{16}\,\mathrm{W\,cm^{-2}}$ intensity could be understood in the case of a DT plasma to be 1.23 $\times$ $10^8\,\mathrm{cm\,s^{-1}}$. This results in a block motion with an ion current density at the target of 1.9 $\times$ $10^{10}\,\mathrm{A\,cm^{-2}}$. Together with this block moving against the laser light, measurements with thin foils confirmed the generation of a similar block moving into the target with similar energy and ion current

density. This result can be related to earlier plane geometry detailed hydrodynamic computations (Fig. 2).

From this result it was concluded that the compressing block may be used as requested for light ion beam fusion for a power station. A 10 kJ laser pulse could then produce 100 MJ of fusion energy where the exclusivity for use for the controlled reaction was confirmed (Hora 2002).

For the physics — within many more problems to be clarified — it has to be shown that at least condition (5) has to be fulfilled. For the compressing block, the whole maximum quiver energy of the electron is converted into translation energy of the ions. The oscillation energy of 80 keV of the resonance maximum of the DT reaction may not necessarily be the best choice. Since this is close to the relativistic threshold intensity I_{rel} (Hora 1991), we have to use the general case,

$$\epsilon_{\rm osc} = {\rm m_o c^2}[(1 + 3{\rm SI_{vac}/I_{rel}})^{1/2} - 1] \qquad (9)$$

where the maximum intensity $\rm I_{max} = SI_{vac}$ due to dielectric swelling near the critical density is expressed by the factor S with the laser intensity $\rm I_{vac}$ in vacuum at the target surface.

For the general analysis we have to be flexible about the chosen values of the applied maximum (dielectrically swelled) oscillation energy, $\epsilon_{\rm osc}$, into the translation DT ion energy, $\epsilon_{\rm trans}$, in adjustment to fusion cross sections. We further leave open the value of the energy flux density $\rm E^* = I_{vac} t_L$ for reaction conditions (5) or (8), or possibly even a lower value depending on future research, to find the correct value $\rm E^*$, where the laser pulse duration, t_L, will have to be in the range of ps. According to extensive numerical studies (Cang et al. 2004) in agreement with summarizing estimations, this value could well be a few ps. From relations (5) or (8) and (10), we arrive at the function for the laser wavelength (11, see bottom of page).

$$\rm I_{vac} = E^*/t_L \qquad (10)$$

Using as a special case $\rm t_L = 3\,ps$, $E^* = 2 \times 10^7 J\,cm^{-2}$, $\epsilon_{trans} = 80\,keV$, we find (12).

$$\lambda = 0.516/{\rm S}^{1/2}\mu{\rm m} \qquad (12)$$

The non-linear force driven two-block skin layer interaction model works for swelling considerably large than 1, as is the case automatically from detailed analysis of measurements (Hora et al. 2002a; Hora 2003; Cang et al. 2004) with S = 3. The lowest possible case, with S = 1, is that without any dielectric swelling where the whole laser pulse energy is transferred as in the simple case of radiation pressure (Hora 1991) to the absorbing plasma. We conclude that the conditions of the kind in (5) or (8) could well be fulfilled for the ignition of uncompressed solid DT fuel when applying shorter laser wavelengths than that of the neodymium glass laser, and which are well within the reach of present technology, as seen with excimer lasers (Teubner et al. 1993). For the pessimistic case of Bobin (1971) and Chu (1972), the numerical factor in (12) is 0.105, such that with S = 1 just the borderline of higher harmonics CPA excimer lasers (Teubner et al. 1996) would be covered. Further research on lower values of $\rm E^*$ and numerical studies for a little longer laser pulses may further relax the conditions, and longer laser wavelengths would be possible. No discrepancy was found in the detailed analysis (Bobin 1971; Chu 1972) when followed up recently (Kishony et al. 2001). Figure 5 shows the dependence of the necessary laser wavelength for a pulse length of 3 ps and swelling S = 1, which one needs for a desired ion translative energy in multiples of $\rm m_o c^2$ ($\rm m_o$ is the rest mass of the electron), if the threshold $\rm E^*$ is given.

$$\lambda(\epsilon_{trans}, E^*, t_L, S) = [t_L I^*_{rel}/(3SE^*)]^{1/2}\ \{[(\epsilon_{trans}/m_o c^2) + 1]^2 - 1\}^{1/2} \qquad (11)$$

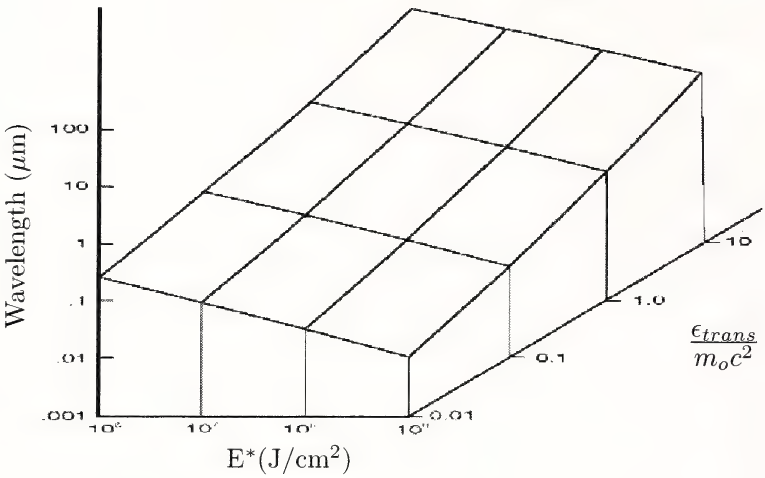

Figure 5. Relation between the laser wavelength, the aimed ion energy, ϵ_{trans}, in multiples of $m_o c^2$, and the necessary energy flux density E^* for ignition of uncompressed solid DT fuel for S = 1 and a laser pulse length of 3 ps.

The gain for a controlled reaction has been estimated to be of a high value. A 10 kJ ps laser pulse may result in 100 MJ fusion energy (Hora et al. 2004). From the block ignition of solid DT without compression there may perhaps be the possibility for neutron lean reaction leading to direct conversion of the nuclear energy of the charged reaction products into electricity (Hora 2002; Hora et al. 2003a).

These developments may be considered in view of the project of the ITER tokamak to be built with \$ 15 billion during the next 10 years in Cadarache/France and which may produce electricity with high gain (Tran 2004). For energy production by controlled inertial confinement fusion, it was demonstrated by the Centurion-Halite project (Broad 1988) that a 50 MJ x-radiation pulse on a fusion pellet produces a very high gain of fusion energy (Phipps 1989) where the computation with the use of a much more sophisticated laser irradiation of 10 MJ instead of the x-rays may produce 1000 J fusion energy (Strom et al. 1988, Hora, Azechi et al. 1998). Since the ignition of large amounts of solid state DT or of some higher density for energy production (Nuckolls and Wood 2002) may be possible by electron beams, the just described block ignition will come closer to the radiation ignition of these very high gain reactions as underlined by Nuckolls (1992). After the necessary conditions of very high energy flux density E^* and the 10^{11} Amp/cm^2 are available now by the just described block ignition it may be indicated that the then interacting 10^{17} W/cm^2 laser intensity is in the range of the 20 million K radiation temperature involved in the ignition processes explained by Nuckolls (1992).

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The Rev. W.B. Clarke and his Scientific Correspondents

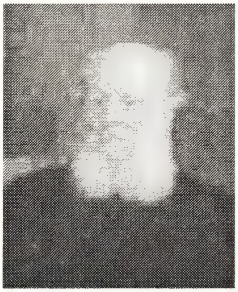
ANN MOYAL

Keywords: W.B. Clarke, Early Australian Science, Geology

INTRODUCTION

It is fitting that my talk should coincide with an Ordinary General Meeting of the Society in view of the fact that W.B. Clarke was the founding father of the Society and I am sure he would be greatly cheered — future-oriented as he always was – to know that this is the 1132nd Ordinary General Meeting at which I am talking about him directly. It is a great record of continuity in the life of a Society which was so important in his life.

I speak of Clarke in this personal way for I have lived with him, on and off, for a very long time — indeed some 40 years! And the reason for this long marriage is that the Clarke Papers represent one of the most important collections in the Mitchell Library of the State Library of New South Wales and are the largest collection of correspondence of a resident scientist in nineteenth century New South Wales. In fact they are probably the largest such collection in Australia. For my part, I came to them in the 1960's with my joint appointment with the Australian Academy of Science and the History Department of the Research School of Social Sciences at the Australian National University to establish an archival centre of twentieth century scientists at the Academy's new Basser Library and to open up research in the history of Australian science. Clarke's correspondence and diaries fertilized my early research and appeared in my books *Scientists in Colonial Australia: A Documentary History* and its illustrated and more general sequel *A Bright & Savage Land.*



In the 1990's, however, aware of the collections of correspondence of major scientists being published in other countries — Charles Darwin in multiple volumes at Cambridge University, Michael Faraday and others, Joseph Henry in the U.S.A. to name a few, and also of the international venture centred at Melbourne University to gather the outgoing correspondence of Ferdinand von Mueller, Government Botanist of Victoria, scattered around world (for his incoming correspondence has been largely destroyed), I decided to select and publish Clarke's scientific correspondence for the remarkable window it opens on Australia's nineteenth century science and its interrelationships with science overseas.

Let me give you first a brief picture of the man and why he emerges, particularly through his correspondence, as such an important figure in this country's science. William Branwhite Clarke (1798 to 1878) was one of that nineteenth century phenomenon, an Anglican clergyman who combined a knowledgeable and keen interest in geology and other natural sciences with his religious calling. Born in East Bergholt, Suffolk, he took his degree in Holy Or-

ders at Cambridge in 1817 and for a period became a curate in various English parishes. But as his prospects of preferment in the Church in England were low, after two decades, he accepted the offer of a chaplaincy in New South Wales and arrived in Sydney with his wife and two children in May 1839.

Importantly, however, Clarke had fallen under the spell at Cambridge and studied with the newly appointed Woodwardian Professor of Geology, Adam Sedgwick, who was to became one of the great figures of British geology, and across the next twenty years Clarke published papers on aspects of British and continental geology and on meteorology, and was elected a Fellow of the prestigious Geological Society of London. When, then, he arrived in Sydney in 1839 at the age of 40, he was the first trained geologist to settle in Australia.

So while Clarke also became an articulate and enlightened member of the Sydney clergy and the first pastor of St. Thomas's Church, North Sydney, from 1846 until his retirement in 1871, it was as a geologist and scientist that he made his mark and to which my volumes published as *The Web of Science. The Scientific Correspondence of the Rev. W.B. Clarke, Australia's Pioneering Geologist* (Australian Scholarly Publishing, 2003) relate.

Significantly, Clarke came to Australia at a time when British geologists were adding fundamental findings to knowledge of the geological structure and systems of Great Britain and turning their particular attention to the classification and ordering of the successive formations of the earth's crust. These were subjects of high importance and controversy in a science that was moving away from broad theory and focusing on geological fieldwork and fossil evidence as the markers of stratigraphical determination. The Geological Survey of Great Britain had begun its work 3 years before, so, that when Clarke landed at the far end of the world and set foot in what he called 'a new earth for geology', he brought with him knowledge of the evolving systems of British stratigraphy, and the skills and precepts of an experienced British geologist.

His early investigations focused on the Sydney Basin, moved by Sedgwick's recommendation that he should make the coal formations of New South Wales the first object of his research. Traveling on horseback, he explored the Illawarra region and the Hunter Valley and up to Lake Macquarie, filling his knapsacks with large collections of fossils, the best of which he sent off for identification and comparison to Sedgwick at his Woodwardian Museum. And it was to Adam Sedgwick that Clarke dashed off his long early letters that so vividly reflect the experience of the pioneering geologist in an unexplored land. They make compelling reading. Attempting to delineate the complex stratigraphy of the Sydney coal basin, he faced the formidable challenges of tracing outcrops of strata over obscure and tangled tracts of land, without the maps, canals, or rail cuttings that aided British geologists in their search.

In June 1841, he wrote to Sedgwick:

'Since I wrote to you, I have had some further opportunities of examining extensive districts in this part of the Colony; and the result of my labours, it is my intention to bring before [Geological] Society in a connected Memoir ...But the difficulties are so great in this country to the Geologist, that after all the most industrious & extensive researches can only lead to any approximation of the whole truth. Owing to the pecular construction of the country, its deep and impassible ravines, its enormous forests, its want of crossroads, and good sections, it is only by most painful plodding, that one can make out anything satisfactory, but hope, with such slender means as I possess. I shall, nevertheless, be the first who has ever laid before the public a connected series of geological observations on a wide extent of Australian land.'

Through the 1840's, snatching time from a huge parish that ran from North Sydney through bushland country as far as Manly, Clarke managed to publish a number of papers on Australian geology in major geological Journals overseas. In 1842 he discovered the Palaeo-

zoic fossil Trilobites in a tributary of the Hunter River which confirmed that Australia was a continent of great geological antiquity and opened the way for the extended classification of Devonian and Silurian rocks in Australia, correlations with British and European stratigraphy that were of first interest to his colleagues in the northern hemisphere.

Clarke was also quickly and keenly involved in meteorological research setting up instruments at his rectory, linking in correspondence and friendship with that other keen meteorological investigator, Admiral P.P. King and with scattered settlers, and writing on the subject and on other scientific topics in the Sydney Morning Herald. It was, in fact, very soon after his arrival in Sydney that he made arrangements with the Herald to communicate articles and editorials on scientific topics, that made Clarke an early and major pioneer of the public communication of science in Australia.

In 1842, however, a significant event occurred which was to transform Clarke's personal and scientific life. His wife Maria Clarke detested the Colony. She hated the convict settlement and the convict servants, and the summer winds that fanned her husband's interests in meteorology, left her exhausted and dispirited. So in January 1842 she plucked up their now three children and sailed for England. She did not return for 15 years when a generous donation from Clarke's parishioners brought her and their now adult children back to Sydney. Her departure, it must be said, was a blessing to Australian science. Left in a solitary state, Clarke accelerated his diverse scientific activities and eager to overcome the tyranny of distance and retain and extend links with his networks 'at home' he became a prolific correspondent reaching out to key figures in Britain and Europe, the United States, India, New Zealand and to particpant naturalists throughout the Australian Colonies.

Much of Clarke's public reputation rested on his work in connection with gold. He himself found gold particles in 1841 and again in 1844 when he took them to show Governor Gipps at Government House in Parramatta when Gipps exhorted him famously in a convict colony, 'Put them away Mr Clarke or we shall all have our throats cut'! Clarke put them away but he wrote increasingly in the Herald on the constants to be looked for in the location of gold and, with the promotion of a gold rush by Edward Hargraves in 1851 Clarke was at once appointed by Government to conduct a Geological Survey on horseback, with a cart and two assigned servants, across New South Wales from Omeo in the south through the Alps, traversing to Ipswich in the north, a distance of some 60,000 square miles, reporting as he went on gold and other metalliferous deposits and the structure of the country in 29 reports to Government.

His Southern and Northern Geological Surveys conducted from 1851–53 for the first time offered him unbroken fieldwork over continuous tracts of country and he pinpointed many areas that were later found productive in gold and identified minerals, notably in New England of copper, lead, tin, iron and precious metals that underlay the economic exploitation of these materials in later years. It is not widely known that Clarke was one of the 200 people named at the Bicentenary for their contribution to the development of Australia and this stemmed from his opening up of mineral wealth. His Reports, published in Colonial and British Parliamentary Papers and extracted in the Sydney Morning Herald, were widely read and served as a guide to diggers, focused Clarke as an authoritative 'public scientist', and made him a household name. They also brought him invitations from neighbouring Colonies and from New Zealand to conduct geological surveys in their regions, all of which in the interests of his church calling, he declined. He also received hundreds of letters across his career from diggers and prospectors which he conscientiously answered, one or two of which I have included in the book.

Throughout the 1850's and 60's Clarke developed his personal communication network which, as in the book's title, I call 'The Web of Science'. In Britain this drew in, in addition to Sedgwick, a lovable but unreliable friend,

such scientific luminaries as the imperious Sir Robebrick Murchison, the palaeontologist Sir Richard Owen, to whom he sent the bones of giant marsupial species, and the younger geologist J.B. Jukes, a personal friend of Clarke's now head of the Irish Geological Survey who had visited Australia in the 1840's as naturalist to the British survey ship H.M.S. *Fly*. From North America it also included that other one-time visitor, the noted mineralogist, James Dwight Dana, who had met and geologised with Clarke in the Illawarra in December 1839 when Dana visited Sydney as naturalist to the United States Exploring Expedition and who, as Professor of Natural History at Yale, continued to communicate with Clarke on geological questions for over 30 years. In July 1872, Dana wrote his old friend warmly: 'The few weeks of intercourse which I had with you in Australia were among the happiest days of my life and I shall never forget your kindness & the scenes we enjoyed together'.

Other participants in the 'web' included the directors of the Geological Survey of India and the New Zealand geologists Julius Haast, James Hector and others, a number of eminent French geologists, and a good scattering of metropolitan and provincial palaeontologists in Britain.

The letters that flow to Clarke from these correspondents — and these are *incoming*, letters which form the greatest part of these volumes — are full of news of recent discoveries, classificatory discourse, the warmth of friendship, discussion of health (so important in the nineteenth century), gossip about colleagues, and the aspirations, achievements, and frustrations that make up the life and sociology of science. Clarke's scientific findings in Australia were grist to his corespondent's scientific mills; his exchange with Murchison over scientific priority in the discovery of Australian gold, was particularly fiery and lively, 'For a clergyman' Murchison at last exclaimed, 'you appear to be very bellicose'! And over all, the myriad people who cross these 896 letters and appear in the many footnotes touch and engage an enormous spectrum of nineteenth century science.

In Australia, Clarke's opportunities for scientific exchange and communication grew with gold. Conspicuously, he was a man who offered great encouragement and friendship to younger scientists, initiating contact, furnishing them with copies of his books and foundation papers and forging strong collegiate bonds. Central among them were the young geologists trained and handpicked in Britain who arrived to man the Geological Surveys set up in Victoria and Tasmania in the 1850's and early 1860's and later, through Clarke's pressure, in Queensland: Christopher Aplin, George Ulrich, Richard Daintree, Norman Taylor in Victoria; Charles Gould in Tasmania. Their letters to Clarke reflect the high importance of this communication flow though in the bustle of colonial fieldwork none of his letters to them have survived. As young Charles Gould moved about Tasmania — dropping the names of famous scientists Darwin, Huxley, and Jukes on the mountains of the west coast — wrote Clarke: 'I have so few opportunities now of communicating ideas that any break in correspondence with yourself amounts to a very positive misfortune'.

The correspondence from these men throws fresh and illuminating light on the nature of Australia's early surveys, the mapping and the mineralogical search, and highlight the constraints and restrictions in a country where geological investigation — as opposed to gold search — was judged a luxury by government. 'Oh for a forty parson power', Daintree, his frequent correspondent once exclaimed in a letter to Clarke, 'to rouse the inert masses of slumbering politicians in Australia'. A later recruit to the geological community, Charles Wilkinson, who traversed much of Clarke's earlier surveys of New England as Geological Surveyor in New South Wales in the 1870's, wrote the old geologist from his camp in 1876, 'I wish I had the pleasure of your company on my travels'. And it was Wilkinson who brought out Clarke's great Geological Sketch Map of New South Wales four years after his death.

Clarke's one failure in his scientific networking and an important one, lay in his relationship

with the Irish paleontologist appointed in 1856 as the first Professor of Natural History at Melbourne University, Frederick McCoy. McCoy, who had first examined some of Clarke fossils at the Woodwardian Museum, fought him persistently and publicly over the age of the coal measures of New South Wales and, as the one palaeontologist in the Australian Colonies for many years, was a source of great frustration and delay to Clarke although he was eventually proved to be wrong. Yet the few but very cold and unceremonious letters from McCoy to Clarke in the collection supply a clear example of the rivalry, dislike and conflict that sometimes animated the life of science.

It was however, Clarke's capacity to engage young scientists which greatly assisted him in his period as the major founding father and first Vice-President of this Royal Society.

Clarke had served as an influential Council member and one time Vice-President of the Philosophical Society of New South Wales established in 1850 before he became a key mover in the restructuring in 1867 of its successor, the Royal Society of New South Wales. As its first Vice-President, he would make this office a key position in the advancement and life of science in the Colony for the nine long years of his reelection. In his Inaugural address in July 1867 he set down his open-minded view of science which he espoused as a creed for the Society. In brief, he said:

'We must strive to discern clearly, understand fully, and report faithfully; ...to adjure hasty theories and unsupported conjectures; where we are in doubt, not to be positive; to give our brother observer the same measure of credit we take to ourselves; not striving for mastery, but leaving time for the formation of the judgment which will inevitably be given, whether for or against us, by those who come after.'

The Royal Society of New South Wales began with a membership of 163. They were an eclectic group made up of scientists, and administrators, from the University of Sydney, a medley of civil servants from the Colonial Departments of Works, Lands, Mining, Surveyor-Generals, and interestingly enough, from the Telegraph Office, and the Sydney Mint, along with a growing corps of professional scientists from the Sydney Observatory, the Botanic Gardens and the Australian Museum. There were also the one-time 'amateurs and gentlemen' — the independent zoologists, entomologists, botanists, and astronomers (most notably here the internationally renowned astronomer at Windsor, John Tebbutt, who gave many papers to the Society), and a large number of physicians, clergymen, members of Parliament and the Stock Exchange, and businessmen and a few schoolmasters and scattered settlers.

It was a major cultural assemblage, and an intellectual force within the Colonial society. And it was in the context of this key scientific community that Clarke's Inaugural message had special significance. He himself had read the *Origin of Species* as soon as a copy arrived in the Colony and at once wrote off to Darwin sending him pertinent geological information which Darwin would include in a later edition. Unfortunately it not possible to know what Clarke actually said about *The Origin* itself in this first letter of August 1861 as the top page in the Darwin Correspondence at Cambridge is missing. But Darwin's response was telling, 'Thank you cordially', he replied in October that year, 'for your very kind expressions towards me & for your letter which has deeply interested me'. 'I am very glad to hear of your new discovery of secondary fossils in N.S.Wales. I have for some time thought that the geology of distant countries would help in the progress of Science more than anything else'. Clarke, for his part, answered Darwin's queries on the glacial period in Australia, sent him a photograph of the Blue Mountains where young Darwin had ridden out in 1836, and was ready to assist the dangerous evolutionist with a botanical experiment relating to bees. By contrast Australia's leading botanist, Ferdinand von Mueller, a man who believed firmly in the fixity of species, declined.

Australian scientists such as Mueller ad-

mired Darwin for his *Journal of Researches into the Geology and natural History of the various countries visited by H.M.S. Beagle*, but, with the notable exception of Gerard Krefft at the Australian Museum, the great majority deplored his theory of evolution by natural selection. Clarke, for his part, was a uniformitarian and an evolutionist in geology who recognized the appearance and extinction of species over infinitely changing eras of geological time, but, like so many major scientists of the period in Britain, he remained a 'Separate Creationist' to the end. 'I believe' , he put his view in a letter to the Sydney Morning Herald in 1869, 'that species as such were made by the Creator, and that they are not the result of accidental conditions, but however related are independent of their predecessors' Nonetheless in a scientific community deeply antipathetic to Darwin's view, Clarke was an exceptional public advocate for an unbiased examination of contemporary scientific ideas.

The two men's friendship grew, anchored largely on geological themes. Darwin linked Clarke with a reputed palaeontologist in Bath — Charles Moore — to classify some of his thousands of fossils (for the problems of the investigator at a remote outpost and without comparative suites of specimens were very real) and, importantly became one of Clarke's sponsors for his election to the Royal Society of London in 1876.

At the Royal Society of New South Wales, Clarke's leadership launched two important initiatives. Firstly, his idea of a 'new earth for geology' was to colour the life of the Society across its first seven years. As the resident authority, scientific adviser to government, and public science communicator, he had long acted as a receiver and synthesing agent for new discoveries and information coming in from geologists and surveyors around the Colonies, and to an extent for the other sciences. Now he brought this rich review of information together in his substantial Annual Addresses. Daintree, appointed to head the Geological Survey of Northern Queensland offered data on Queensland's expanding gold and other mineral discoveries and his unique photographs and information flowed in from surveyors and scientists around the country. These Addresses became important annual overviews of advancing knowledge in Australian science. They were reprinted in the Sydney Morning Herald — those were the days for serious science communication! and Clarke disseminated them tirelessly to colleagues and institutions at home and overseas.

Simultaneously, on a second front, Clarke was reaching out to the two new highly qualified British appointees in Geology and Chemistry at Sydney University, the delicate young Dr Alexander Thomson, Reader in Geology from 1866–72, and Archibald Liversidge who succeeded Thomson on his early death to become Professor of Geology and Mineralogy in 1874 and later influential Professor of Chemistry. Clarke bound the two young men to him, recruiting them to the Council of the Society, geologizing and sharing geological discoveries with Thomson, and drawing on their interest and skills in assaying the many mineral specimens that flowed to his desk. Their letters shed light on the Society's affairs. In particular Clarke's many letters to Liversidge who become Secretary of the Society for a decade from 1874, and a scientific maker and shaker himself, reveal the Society's internal functioning, the search for funding from Government and for their own building, the formation of sub-committees, the choice of honorary members, Clarke's famous portrait by Aniviti in 1875, and pieces of the trivia and gossip that figure in the life of all societies.

'Will you — would you' writes the 76 year-old Clarke to young Liversidge all of 28 from his home on the North Shore in 1874, addressing him carefully now as 'Professor', 'let me have the pleasure of a conversation with you here as soon as you can conveniently come over. I am unable to stir out being under treatment for a violent attack in the eyes which has kept me a prisoner since we met on the *Challenger*.' (p1 037).

The language and cordiality of the communication of scientists in these long lost days, refreshes and adds pleasure to the reading.

The letters of Clarke to Liversidge (retrieved after Clarke's death) focus his close paternal role in the Society's affairs. At the time of his departure as Vice-President in 1876, membership numbers had risen from the initial 163 to 348 and, so wide had the scope and compass become of scientific interests that flourished in the Society and flowed into its *Transactions*, that by 1877 some seven different working sections had been formed.

Significantly Clarke stood on the cusp of change as science moved from the domain of the independent scientist to an increasing professionalization and institutionalization, a movement he was able to foster and advance. His own work gathered substance from the first publication of his *Remark on the Sedimentary Formations of New South Wales* in 1867 through to its fourth and final edition in 1878 which encompassed much of the classifications of his fossil collection. Yet, in the event, it was not the scientists at the Imperial centre with whom he had long correspondence who assisted him in this but Professor Laurent de Koninck, distinguished palaeontologist at the University of Liege in Belgium, to whom he had been recommended and who carried out the classification of Clarke's Palaeozoic and Carboniferous fossils in a collaboration and correspondence across the world conducted entirely in French. In these volumes, de Konick's letters full of warmth and friendship, appear translated into English by the distinguished linguist the late Dymphna Clark.

In 1877 the Geological Society of London honoured Clarke with the award of the Murchison Medal and a purse of gold 'in recognition of his remarkable services in the investigation of the older rocks of New South Wales' . The previous year he had been elected at last to the Royal Society of London. With Darwin and the philosopher U. S. Jevons as his sponsors. His election was not in doubt. As the Society's Secretary wrote him: 'both Hooker and Huxley were warm in your favour, so that you came in, it may be said, triumphantly'.

When I first began exploring W.B. Clarke's work and Papers, the view was generally held by contemporary geologists in Australia that Clarke was just one of a small group of the early pioneers. His correspondence tells a different story. Through his extensive networking as well as his tireless independent scientific investigations, his position as a prominent public scientist with strategic relations with governors and governments, and his leadership role in building a scientific community, Clarke emerges as both the Colony's key scientific savant of his period, and a polymath. Moreover, (unlike other nineteenth century scientists in Australia who variously conducted correspondence in their fields) Clarke had the good Judgment and the foresight to perceive the value of this correspondence and to preserve it for posterity. He thus became the custodian of the historical record and gave us a ticket of entry to our scientific past.

Clarke, of course, was not perfect. He was highly ambitious in his geological researches, concerned for recognition and priority, and often outspoken and controversial in some of his anonymous (though clearly identifiable) writings in the Sydney press. Yet, alongside my historical evaluation, it is interesting to read this perceptive contemporary comment in 1878 at his death. 'When geology was yet unknown' wrote an unknown obituarist, 'who could estimate the immense gain to our young Colony to have a man like Clarke at our disposal. He excited an interest in the subject; he never ceased to bring the prime interest of his life before the public. He was a centre around which all facts and discoveries were sure to group themselves'.

For their part, the Royal Society of New South Wales, also showed contemporary judgment and foresight when at Clarke's death they struck Australia's first scientific medal in his name.

'We have buried the Rev.W. Clarke', wrote the New Zealand geologist, Thomas Hacket, stationed in Australia to his compatriot, James Hector in July 1878. 'There were some 200 gen-

tlemen present at his funeral on the north shore including some 20 clergymen, and a great number of the Royal Society and many notabilities and friends' . His bones have been scattered in the old cemetery at St Leonards now a pleasing park, but Clarke's name has continued to focus the contribution of Australian scientists to the natural sciences across the past 127 years.

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Thesis Abstract: Workplace Violence Ltd.

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Abstract of a Thesis submitted for The Degree of Doctor of Philosophy
University of Otago, Dunedin, New Zealand, May 2004

Keywords: workplace violence, discourse, discourse analysis, undecidability.

In the rush to solve the problem of workplace violence there have been few pauses for critical reflection. Many academic writings on workplace violence are content to rely on a self-evident representation of violence to inform understandings. This reliance not only breaks a basic rule of method by taking for granted the very phenomenon to be analysed but also risks erasing or marginalising other understandings of workplace violence. Addressing the research problem — how do representations of violence shape the discourse of workplace violence — considers these limitations and difficulties.

A perceived epidemic of workplace violence has received considerable attention from management and organisation scholars. Much of the literature on workplace violence is anxious to point out the increasing rate and severity of workplace violence, offering a wealth of 'evidence' of an escalating trend. Some claim workplace violence has reached 'alarming numbers' and is the number one issue that 'worries companies most.' In response to these sorts of claims, a steady stream of regulatory guidelines and 'practical' managerial advice has emerged offering employers and government agencies 'solutions' to the problem of workplace violence. Yet, a considered treatment of violence expected of a scholarly account appears unnecessary — and even luxurious — in the face of the obvious and bloody 'reality' of workplace violence.

Wary of grounding workplace violence in these terms, this thesis engages with a broader tradition of philosophical reflections on violence to provide alternative representations that directly confront the sense of certainty evident in writings on workplace violence. Given these alternative representations, the difficulty lies in refusing to see violence as a simple formula while also resisting indeterminacy. In order to navigate through this complex situation, violence is considered as undecidable. This move draws attention to the way in which decisions are made in concrete everyday situations, what grounds these decisions, and their effects.

Thus utilising a discursive framework, and drawing on the work of Michel Foucault, this thesis critically explores the assumptions about violence that inform discussions of workplace violence. An analysis of an archive of 87 workplace violence texts published in the field of management and organisation studies contends that violence is represented as a set of deviant behaviours committed primarily by employees. Such a representation rests on a number of unacknowledged assumptions that limit alternatives and reflect particular relationships of power. Violence is limited to 'sovereign' manifestations where workplace violence is a problem *for* organisations rather than a problem *of* organisation.

In working through these arguments, this thesis indicates the taken for granted codes that shape research into workplace violence. Reflecting on the concept of violence and its sense of certainty will have important implications for considering the context in which violence is understood, experienced, tolerated, accepted or rejected by members of society. This might invite pause for reflection when we see various actions represented as violence. It might also invite us to reflect on the way that so many of the violences of today are treated as if they were something else.

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Thesis Abstract: Growth, Structure, and Desalination of Refreezing Cracks in Sea Ice

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Abstract of a Thesis submitted for the Degree of Doctor of Philosophy
University of Otago, Dunedin, New Zealand 2004

The aim of this study is to characterise the structure of refrozen cracks, and to deduce the details of their formation. Surveys and experiments are conducted on straight-sided, linear, refrozen cracks of width 80 mm to 340 mm in land-fast first-year sea ice in McMurdo Sound, Antarctica.

Refreezing of cracks is simulated analytically, and with a numerical fluid dynamics model of brine movement in the porous sea ice and in the ocean. Systematic arch-shaped patterns of inclusions, upstream-growing crystals, and two-dimensional variations in salinity are identified in completely and partially refrozen, natural cracks, and in artificial cracks.

Using a two-dimensional thermistor array, a relationship between the development of the sea ice structure and the temperature records is found, which identifies the transition from the porous, skeletal layer to consolidated ice in artificial cracks. A two-dimensional analytical model is developed that predicts the measured thickness of consolidated ice in refreezing cracks for this study and for the studies of others. From a heat balance within the refreezing cracks, it is concluded that some of the experiments were conducted in the presence of a negative ocean heat flux. A two-dimensional thermistor array beneath the ice-water interface of a refreezing crack provides evidence for sporadic, cold temperature, advective events at night.

A two-dimensional, numerical fluid dynamics model based on the finite volume method is developed to simulate desalination and fluid flow in refreezing cracks. This requires a permeability-porosity relationship for sea ice, which is deduced from data of other groups, combined with the numerical model. To make comparisons among data sets, an analytical approximation is derived for the relationship between connected pore space and total pore space of a random porous medium, based on a Monte Carlo model that is adapted to the crystal structure of sea ice. The permeability-porosity relationship derived in this study is in good agreement with permeability functions published recently.

The refreezing of cracks simulated with the numerical fluid dynamics model is consistent with experiments and with the analytical model. In addition, the numerical model simulates the high porosity, arch-shaped freezing front and inclusion structure. Supercooling of the liquid is found to cause excessive heat loss in the simulation. Since a large oceanic heat flux was not observed in the experimental heat balance of refreezing slots, it is suggested that this indicates platelet ice formation or frazil ice formation at the vertical crack interface in Antarctic experiments.

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Thesis Abstract: A Software Engineering Approach to the Integration of Computer Technology into Mathematics Education

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Abstract of a Thesis submitted for the Degree of Doctor of Philosophy
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In this thesis we explore, from the perspective of the software engineer, the application of computers to the teaching of secondary school mathematics. We identify ways in which the uptake of computers in mathematics teaching can be encouraged, and show how the software engineer, working in partnership with the teacher, can play a pivotal role in enhancing teachers' use of technology.

By conducting a number of interviews and undertaking several case studies with practising secondary school mathematics teachers, we identify what we believe to be the key factors influencing the integration of computers into the classroom. These factors range from the adequacy of teacher training through to the design of appropriate didactic software. Our emphasis throughout is on the role the software engineer can play in the creation of software that will be used successfully by the teacher and will make a significant contribution to the overall teaching of mathematics. Cooperative teacher and software engineer partnerships are trialled in depth through the case studies. The outcome is the development of a software architecture aimed at creating educational software products that are adaptable to the pedagogical and epistemological orientations, and consequently the teaching practices, of individual teachers.

In the course of our investigation we:

§ explore the various views mathematics teachers have of integrating technology;
§ model the major factors influencing the integration of technology by mathematics teachers, and explore how these factors interrelate;
§ explore processes of co-developing educational software with mathematics teachers;
§ suggest how teacher training can be modified to more effectively encourage and assist mathematics teachers to integrate computers;
§ categorize the various types of mathematics educational software;
§ categorize the various educational tasks found in mathematics software; and
§ develop an underlying reference architecture to create mathematics educational software that can be readily adapted to meet teachers' individual needs.

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Thesis Abstract: The Ecology of a Host-Parasite Relationship: Haemogregarines & the Eastern Water Skink, Eulamprus quoyii.

DANIEL J. SALKELD

Abstract of a Thesis submitted for the Degree of Doctor of Philosophy
James Cook University, Queensland 2004

The study of wildlife disease has gained importance in the last two decades as a result of theoretical insights into its possible roles in host evolution, population biology and ecology. However, knowledge of how hosts and parasites interact in natural systems remains limited, and there is a critical need for further research. Therefore, this thesis examines the ecology and interactions between wild populations of hosts, the eastern water skink, *Eulamprus quoyii*, and a parasite, the haemogregarine protist *Hepatozoon hinuliae*.

I carried out a two-year mark-recapture study of eastern water skinks at Blackdown Tableland, Queensland, Australia, and analysed blood slides to measure haemogregarine blood parasite infection. Prevalence (the proportion of the host population infected) increased with host age, did not differ between the sexes, and varied little during the two-year study. Parasite load (the intensity of infection within individuals) was significantly higher in males than in females, and is highly correlated in individuals over time.

Eastern water skinks are viviparous, and therefore reproductive output can be accurately measured by housing pregnant females in captivity shortly before they give birth. High haemogregarine loads reduced female water skink fecundity, by approximately one offspring per litter, compared to females with low parasite loads. Body condition and fat reserves were not responsible for this reduced fecundity. There was no effect of maternal haemogregarine parasite load on offspring size/number trade-offs, or on the performance of offspring measured by growth rates, sprint speed or competitive ability.

Using microsatellite markers, I carried out a preliminary investigation of the effect of blood parasites on female mating strategy. Fifty percent of analysed litters showed evidence of multiple sires, but the propensity to multiple mating was unaffected by female haemogregarine parasite load.

Because *Eulamprus quoyii* occupies a large geographical range spanning the Australian tropical and temperate zones, I investigated whether patterns of parasite abundance are affected by climate. Parasite load, but not prevalence, is related to temperature, but is independent of rainfall.

In conclusion, I argue that haemogregarine blood parasites affect the life-history of their natural host, the eastern water skink, and that continued study of the Blackdown Tableland population should offer further insights into the evolutionary ecology of a wild host-parasite relationship.

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Annual Report of Council

For the year ended 31st March 2005

PATRONS

The Council wishes to express its gratitude to His Excellency the Governor-General of the Commonwealth of Australia, Major General Michael Jeffery AC CVO MC (Retd) and Her Excellency Professor Marie Bashir AC, Governor of the State of New South Wales for their continuing support as Patrons of the Society during their respective terms of office.

Council wishes to extend their thanks to His Excellency the Governor-General of the Commonwealth of Australia, Major General Michael Jeffery AC CVO MC for addressing the Society's Annual Dinner on 11*th* March 2005 and for presenting the 2004 Edgeworth David Medal, Clarke Medal and Walter Burfitt prize.

MEETINGS

Nine Ordinary General Meetings and the 137*th* Annual General Meeting were held at Sydney University

SPECIAL MEETINGS AND EVENTS

4th November 2004

Joint Royal Societies Meeting — the first meeting of all the Australian State Royal Societies

The first ever meeting of all the State Royal Societies of Australia was held at the Darlington Centre, University of Sydney on Saturday 4*th* November 2004. This meeting was arranged at the instigation of the President of the Royal Society of NSW, following a meeting of the President and two Members of the Executive in March 2004 with our Patron, His Excellency, Governor-General Major General Michael Jeffery AC, CVO, MC. At this meeting the Governor-General showed a great deal of interest in our Society and was keen to see greater co-operation between all State Royal Societies.

The Joint Meeting of the Royal Societies lasted all day and included a buffet lunch served at the nearby Society's Office in Darlington Road. In the late afternoon, a reception was given for the Joint Royal Societies by Their Excellencies the Governor-General Michael Jeffery and Mrs Jeffery at Admiralty House, Kirribilli. Our other Patron, The Governor of NSW, Professor Marie Bashir and her husband Sir Nicholas Shehadie were also present. Following the reception a Dinner was held at the American Club in Macquarie Street, which is on the 15*th* floor overlooking the Botanical Gardens and the Harbour.

A major outcome of the meeting was the establishment of personal contacts between Council Members from different states, the exchange of views and some helpful discussions of common problems. We are now exploring the idea of re-establishing the Royal Society of Australia (which received Royal Assent in 1931) as an umbrella organisation for all the State Royal Societies of Australia. We will keep members informed as developments occur.

23rd February 2005

The Society was a co-sponsor of the annual 2005 Joint Meeting of the Four Societies comprising the Australian Institute of Energy, Australian Nuclear Association, Engineers Australia (NUC Engineering Panel), and The Royal Society of New South Wales. The meeting was held in Harricks Auditorium, Ground Floor, Engineering House 118 Alfred Street, Milson's Point.

The 2005 Meeting was hosted by Engineers Australia and the Speaker was Dr Doone Wyborn who spoke on the topic of Geothermal Energy in Australia. Around 15 Members of the Royal Society of NSW attended as part of a capacity audience.

11th March 2005

The Annual Dinner of the Royal Society of New South Wales was held on the evening of Friday, 11th March 2005 at the Forum Restaurant, Darlington Centre, City Road, Sydney University. The after-dinner address was given by His Excellency the Governor-General of the Commonwealth of Australia, Major General Michael Jeffery AC CVO MC (Ret'd) who then presented the Society's Awards for 2004 following the reading of Citations by Professor Jak Kelly.

MEETINGS OF COUNCIL

Three meetings of Council were held at the Society's former Office at 6/142 Herring Road, North Ryde. In July the Society relocated its Office to 121 Darlington Road at the University of Sydney, for which we are grateful to the Vice Chancellor, Professor Gavin Brown AC. The remaining seven meetings were held at the new premises.

PUBLICATIONS

Journal

Vol. 137, Parts 1 & 2 was published in August 2004. This issue contained one peer-reviewed paper on Archaeology (Cult and Archaeology in Pella in Jordon) by Stephen J. Bourke plus the Presidential Address for 2004 outlining the history and future direction of the Royal Society of New South Wales. This issue also contained the Citations for three Awards: the 2003 Edgeworth David Medal; 2003 Clarke Medal (Zoology); and 2003 Royal Society of New South Wales Medal.

Vol. 137, Parts 3 & 4 was published in December 2004. This issue contained two peer-reviewed papers — the first on Gemstones (Gemstone Characteristics) and the second on the Cave Mineral, Aragonite (Studies on Aragonite and its Occurrence in Caves). This issue also contained the Biographical Memoir of Frederick Charles Loughnan who was a member of the Society covering a period of 25 years and published a number of significant papers in the Societies Journal. Vol. 137 also contained the Annual Report of Council for the year ending 31^{st} March 2004 along with the full Financial Statements by the Auditors and Council for the years ending 31^{st} December 2002 and 31^{st} December 2003.

There has been increasing interest on the part of MSc and PhD graduates wishing to have Abstracts of their thesis published in the Journal and a total of 27 Abstracts were published in Vol. 137. Once published, these Abstracts are also published on our web site.

Council wishes to thank all the voluntary referees for their time and efforts and wishes also to thank Dr M. Lake for his voluntary assistance in preparing and typesetting the master pages for printing and for maintenance of the Society's web site. Council also wishes to thank the volunteer helpers who assisted in the production and distribution of the Journals

The Society received various requests for permission to reproduce material from the Society's earlier volumes of its 'Journal and Proceedings'.

Bulletin

Bulletin Nos 272 to 282 were published during the period 2004–2005. Council extends its appreciation to the various authors of short articles for their contributions and to other voluntary helpers who assisted in the production and distribution of the Bulletin.

AWARDS

Council made the following awards for 2004:

Edgeworth David Medal 2004:
Dr Cameron Kepert (University of Sydney)

Clarke Medal 2004 (Geology):
Professor Ian Plimer (Uni. of Melbourne)

Walter Burfitt Prize 2004:
A/Professor Brett Neilan (Uni. of NSW)

Citations for these Awards will be published in the next Volume of the Journal.
The James Cook Medal and The Archibald Ollé Prize were not awarded in 2004.

The 2004 Royal Societies of Australia Eureka Prize of $10,000 for Interdisciplinary Scientific Research was awarded to Vision Cooperative Research Centre of the University of New South Wales for revolutionary research into the development of an implantable contact lens as a simpler and less invasive alternative to refractive surgery for correction of long and short-sightedness. The research changes the way people think about the future of vision correction. Our thanks to the judges; Dr Bill Birch (Museum of Victoria), Prof. Jak Kelly (Physics, University of Sydney), Prof. James Warren (Biological Sciences, Monash University) and Prof. Peter Williams (Minerals and Material Group, University of Western Sydney).

The Award Ceremony was held at Fox Studio in Sydney on the evening of 10th August 2004. The Royal Societies of Australia Eureka award is the first co-operation between the State's Royal Societies and we are now discussing future projects together.

MEMBERSHIP

At 31^{st} March, 2005, Membership of the Society was:

Patrons	2
Honorary Members	10
Full Members	242
Associate Members	17
Total (incl. Spouse Members)	271
Unfinancial*	6
Resignations	21
New members admitted	31

(* removed from membership)

LIBRARY

Acquisition of journals by gift and exchange has continued during 2004/5. Exchange material from overseas sources has been forwarded to the Dixson Library, University of New England in Armidale where it is available locally or on inter-library loan. Australian journals and other printed material are kept in the Royal Society's collection at its office. The Office is located at 121 Darlington Road, Darlington Campus, Sydney University. Items in the collection are available for browsing to members and approved visitors.

Council thanks the staff of Dixson Library for their continuing maintenance of the Society's Collection. The Dixson Library advises the Society of any missing issues of overseas journals and appropriate action is then taken. An accession list of literature received during the year has been compiled and appropriate notices will appear in the Society's Bulletin for the information of members.

The position of Hon Librarian was filled during 2004 by Ms Christine van der Leeuw who was co-opted to Council and has agreed to continue in this capacity during 2005/6. Ms. van der Leeuw comes with extensive Library experience and qualifications.

ABSTRACT OF PROCEEDINGS

7^{th} April 2004

The 137^{th} AGM and the $1{,}124^{\text{th}}$ Ordinary General Meeting were held in Conference Room 1 of the Darlington Centre, Sydney University. The Annual Report of Council and the Annual Financial Report by the Auditors were presented and accepted by the Members. The Presidential address was delivered by Karina Kelly entitled '2021 – Science Past and Future'.

12^{th} May 2004

The 1125^{th} Ordinary General Meeting opened at 7 pm in Lecture Room 3, Institute Building, Sydney University, 174 City Road, Darlington on Wednesday the 12th May. The talk, entitled *How old is life on earth?* was given by Prof. Malcolm Walter, director of the Australian Centre for Astrobiology at Macquarie University. Prof. Malcolm Walter has worked for 35 years on the geological evidence of early life on Earth, including the earliest convincing evidence of life. Since 1989 he has been funded by NASA in their 'exobiology' and 'astrobiology' programs, focus-

ing on microbial life in high temperature ecosystems, and the search for life on Mars. He is a member of the Executive Council of NASA's Astrobiology Institute. During 1999 his book 'The Search for Life on Mars' was published by Allen & Unwin. He has published more than 100 articles and several other books. He also works as an oil exploration consultant and a consultant to museums, and was curator of a special Centenary of Federation exhibition on space exploration (for the National Museum of Australia in Canberra, Museum Victoria, and elsewhere).

5th June 2004

The 1126*th* Ordinary General Meeting was held at Sydney Observatory, Observatory Hill at 4 pm. The talk, entitled *Transit of Venus: The Voyage of the Endeavour* was presented by Antonia Macarthur, researcher, historian and author with the HM Bark Endeavour Foundation who discussed some little known aspects of the Endeavour voyage of 1769. The visit included a special viewing of the Transit of Venus exhibition, including Cook's log of the 1769 transit. This was followed by 3D Space Theatre and telescope viewing until 9:00pm.

In June, the Society joined the Sydney Observatory's events to commemorate James Cook's observation of the Transit of Venus in the lead up to the first such event in 122 years.

7th July 2004

The 1127*th* Ordinary General Meeting opened at 7.00 pm in Lecture Room 3, Institute Building, University of Sydney. The talk was given by Prof. Brendan Kennedy on *Synchrotron Science — An Australian Perspective.*

In 2001, the Victorian Government decided to fund the construction of a 3 GeV synchrotron. For Australian researchers using synchrotrons this was very good news. They'd spent the last 10 years practicing 'suitcase' science travelling the world to access synchrotrons overseas. The Australian Synchrotron Research Program, which has operated beamlines at Synchrotrons in Japan and the US since 1993, is a victim of it's own success and these beamlines cannot meet the existing level of demand. Internationally, there are 43 established synchrotrons, with 12 under construction and 19 more in the planning stages. Most developed countries have one or more. A major attraction of any synchrotron is their ability to enable 'small science' to be done. This talk described what it is that makes a synchrotron so important in many areas of research.

4th August 2004

The 1128*th* Ordinary General Meeting opened at 7:00pm in Lecture Room 3, Institute Building, University of Sydney. The talk was given by Professor Tony Hulbert, University of Wollongong, on *Life, death and the membrane pacemaker theory*

Metabolism is fundamental to life and the relative rate of this metabolism can vary more than 100-fold between different animal species. It's only recently that a mechanism has been proposed to explain it this variation. It's called the membrane pacemaker theory of metabolism, which proposes that the types of fats that make up cell membranes determines the metabolic rates of cells, tissues and consequently whole animals. Small species which have high metabolic rates have polyunsaturated membranes, while large species which have low metabolic rates have monounsaturated membranes.

Professor Hulbert explained his theory which has important implications for some of the disease states that plague us such as depression, insulin-resistance and obesity.

1st September 2004

The 1129*th* Ordinary General Meeting opened at 7:00pm in Lecture Room 3, Institute Building, University of Sydney. The talk was given by Dr David Mills, Head of the Solar Energy Group, Physics Department, Sydney University, who spoke on *Low Cost Solar Thermal Electricity.*

The first stage of a 39 MW solar thermal electricity plant has been constructed and is being tested prior to expansion and connection to an existing coal-fired plant at Liddell in NSW. The plant will eventually consist of 135,000 m^2 of reflector, and will be the largest solar plant

built anywhere in the world since 1990, yielding three times the peak power of all the photovoltaic solar power installed in Australia.

Design efforts are beginning to move toward very large stand-alone solar plants incorporating storage. Calculations for a 240 MW plant are being developed for an Australian generating utility, and the first proposed site is being monitored for solar beam radiation. Preliminary costings suggest the technology has the potential to be competitive with coal generation in some areas.

13th October 2004

The 1130th Ordinary General Meeting opened at 7:00pm in Conference Room 1, Darlington Centre, University of Sydney. The talk was given by Prof. John Shine, Executive Director, Garvan Institute of Medical Research, Chair, NHMRC and Vice President, Australian Academy of Science, who spoke on *Humanity's Future — Understanding our Genome*. The audience discovered why the Human Genome is changing the face of medicine.

Completion of the human genome sequence has changed forever concepts of pharmaceutical development and preventative medicine, providing rapidly growing insight into the nature vs. nurture debate. The parallel sequencing of bacterial and viral genomes is also providing powerful new tools in the ongoing war against ever changing infectious agents. Similarly, progress in stem cell biology is fuelling hopes of cell based therapies to reverse a range of degenerative conditions and improve our quality of life. Together these advances are leading to a future where the emphasis is on the 'individualisation' of prevention and treatment, based on both genetic makeup and environmental circumstances.

While this exciting science will underpin and greatly accelerate future developments in virtually all areas of medicine, it is also leading to a sense that humanity is at the threshold of reworking its own biology, of controlling its own evolution - a concept that troubles many in the community.

3rd November 2004

The 1131st Ordinary General Meeting opened at 7:00pm in Conference Room 1, Darlington Centre, University of Sydney. The speaker was Robyn Williams, ABC Radio and Television Broadcaster and author who presented *40 Years of the ABC Science Unit*. Members and visitors heard one of Australia's Living National Treasures speak about his decades of reporting science in Australia and around the world, the highlights and low points, what he learned along the way and tales from the road of Australia's best-loved and most experienced science broadcaster.

2nd February 2005

The 1132nd Ordinary General Meeting opened at 7.00 pm in Conference Room 1, Darlington Centre. The speaker was Dr Ann Moyal AM who presented *Rev. W. B. Clarke — 19th Century Polymath and his Scientific Correspondence*. Dr Moyal is a leading historian of Australian Science, a graduate of the University of Sydney and a Doctor of Letters from the Australian National University. She is the author of many books and papers. Dr Moyal spoke on the topic of her book that was recently launched at the State Library: "The Scientific Correspondence of the Rev. W B Clarke, Australia's Pioneer Geologist". The Rev. W.B. Clarke was an early founding member of the Society and served as inaugural and an influential Vice President for seven years.

23rd February 2005

The Four Societies Meeting is a meeting of the Nuclear Engineering Panel of Engineers Australia, Australian Institute of Energy, Australian Nuclear Association and the Royal Society of NSW. The meeting opened at 6.00 pm in Harricks Auditorium, Ground Floor, Eagle House, 118 Alfred Street, Milsons Point and was hosted by Engineers Australia. Dr Doone Wyborn, Executive Director, Geodynamics was the Guest Speaker on the topic of *Geothermal Energy in Australia*. Geodynamics have drilled one well in the Cooper Basin of South Australia to a depth of 4.5 km, intersecting rock in ex-

cess of 240°C, and have a second well underway. They expect to start production in 2006.

11th March 2005

The Royal Society of New South Wales Annual Dinner was held in the Forum Restaurant, Darlington Centre, Sydney University. The Society's Patron, His Excellency, Major General Michael Jeffery AC CVO MC (Retd), Governor-General of the Commonwealth of Australia, presented the 2004 Awards.

Council for 2004/2005

At the 137th Annual General Meeting held on the 7th Apr 2004, the following Members were elected to Council for 2004–2005:
President: Ms Karina Kelly
(immediate past President of 1 year)
Vice Presidents:
Mr D.A. Craddock
Prof. W. E. Smith
Mr C.F. Wilmot
Mr J.R. Hardie
(1 vacancy)
Hon. Secretary (General): Prof. J C Kelly
Hon. Secretary (Editorial):
Prof. P A Williams
Hon. Treasurer: Dr R.A. Creelman
Hon. Librarian: vacant
Councillors:
Dr A. Binnie, Mr M. Wilmot
A/Prof. W A Sewell, Mr R.W. Woollett
Dr E. Baker, Dr M. Lake & Dr M. Hall
Southern Highland's Branch Rep.:
Mr H.R. Perry

Relocation of the Society's Office to the University of Sydney

In July of 2004, the Society's relocated its Office to 121 Darlington Road, University of Sydney. This followed Council's acceptance of an earlier offer from the Vice Chancellor of Sydney University of premises at Sydney University.

SOUTHERN HIGHLANDS

The Southern Highland Branch held nine meetings (attendance averaging 65 members and visitors at each meeting). Due to building works at Frensham School, meetings were held in a number of alternate locations. The Branch has sent out 60 monthly Newsletters to members and about 150 notices of meetings each month to other interested people.

The Branch Committee for 2004/2005 was:

Chairman:	Mr H.R. Perry BSc
Vice-Chairman:	Mr C.F. Wilmot
Hon. Secretary:	Commander D.J. Robertson C.B.E.
Hon. Treasurer:	Ms Christine Staubner
Member:	Miss Marjory Roberts

ACKNOWLEDGMENTS

The Chairman of the Southern Highlands Branch, Mr H.R. (Roy) Perry expresses to Ms Julie Gillick, Head of Winifred West Schools Ltd and her staff who have generously provided our venue, the management of Fitzroy Inn who allowed us to use one of their rooms for a meeting and for their wonderful after-meeting dinners, the many fine guest speakers who visited us, the Council of Society for its support and the local Branch Committee for their hard work.

Annual Report of Southern Highlands Branch

For the year ended 31st March 2005

This was a special year for the Branch because 2004 marked the 10th anniversary of the inaugural meeting. During this year attendances remained at an encouraging level, averaging 65. A total of 10 meetings was programmed but only 9 actually took place.

Meeting No. 92, 15th April 2004

Because our usual venue was not available, this meeting was held at Fitzroy Inn, Mittagong. We had 2 speakers, Mrs Gwenda Robb and Mr Barry Tombs.

Mrs Robb, member of several historical and fine arts societies, is the author of the book 'George Howe, Australia's First Printer'. She described the life and times of George Howe from his birth in St. Kitts in 1769 in the West Indies to his death in Sydney, N.S.W. in 1821.

Mr Tombs is a retired printer and a collector of printing presses. He explained how some very early presses work and showed slides of some of the items in his collection. 51 members and friends were at the meeting.

Meeting No. 93, 20th May 2004

This meeting was held in the lecture room at Frensham School, Mittagong. On this occasion the meeting was designed to celebrate the Transit of Venus which occurred during the month. The speaker was Dr Fred Watson of the Anglo Australian Observatory.

In his talk entitled 'In the Face of the Sun — Planets and Transits', Dr Watson explained how transits occur and went on to describe various observations of the Transit of Venus from the time of the invention of the telescope to Captain Cook's voyage to Tahiti in 1769. 91 people were at this meeting.

Meeting No. 94, 17th June 2004

This meeting, the first to be held in our new venue, the School Hall, Gib Gate School, Mittagong, was very special for us, being our 10th Anniversary Meeting. Our special speaker was the President of the Royal Society of N.S.W., Ms Karma Kelly. Her topic was 'The Royal Society of N.S.W. — Past and Future'.

Dr Kelvin Grose, whose foresight and initiative brought the Southern Highlands Branch into existence in 1994 and Mr John Hardie who, as President of the Royal Society at the time, presided over our first meeting were in the audience. 65 people were at this meeting.

Meeting No. 95, 15th July 2004

This meeting was held in the School Hall, Gib Gate School, Mittagong. Dr Wayne Johnson was the lecturer on this occasion and his topic was 'Archaeology of Ankor — The World's Largest Archaeological Site'. 79 people were in the audience.

Meeting No. 96, 19th August 2004

The meeting was held in the School Hall, Gib Gate School, Mittagong. The topic 'How Old is Life on Earth?' was discussed by Professor Malcolm Walter.

After describing techniques developed for the exploration of Mars and how they can be developed for terrestrial use, he presented evidence to support the view that micro-organisms first began to appear on earth about 3.5 billion years ago. 67 members and friends were in the audience.

Meeting No. 97, 23rd September 2004

This meeting was held in the School Hall, Gib Gate School, Mittagong. Our lecturer was Mr Peter Churchill, Director of the Canberra Deep Space Communications Centre. His topic was 'Peripatetic Probes Performing Deep Space Pirouettes or Interplanetary Communications in Support of Science'.

He explained how continuous communication is maintained with space probes from 3 base stations, in California, in Spain and in Australia, near Canberra. After this he gave some idea of the very long and complex plan-

ning required to produce a successful mission which may take several years to complete. The audience consisted of 48 people.

Meeting No. 98, 21st October 2004

This meeting was held in the School Hall, Gib Gate School, Mittagong. On this occasion Dr Anna Binnie presented a lecture 'Australia's Nuclear Reactors — A Short History'.

She began with an explanation of nuclear terminology and a description of Nuclear Fusion and Nuclear Fission. Then followed an account of Australia's nuclear reactors from 1940s to the present day including those planned and never built and those actually built. There were 59 people present at the meeting.

Meeting No. 99, 18th November 2004

This meeting was held in the School Hall, Gib Gate School, Mittagong. The speaker was Dr Peter Robinson, of the Physics Department, the University of Sydney and the brain Dynamics Centre at Westmead Hospital. In his talk, 'Understanding Brain Waves' he explained how, since the discovery of electrical activity on the brain by William Caton in 1875, the understanding of the relation between this activity and what is actually going on in the brain slowly developed. He then described how some results of the use of the techniques of physics has enabled successful predictions of phenomena to be achieved. 59 people were at the meeting.

Meeting No. 100, 24th February 2004

Meeting No. 100 was planned to be held on 24th February, 2004. Unfortunately the lecturer for this meeting was unable to attend and the lecture was postponed and the meeting cancelled.

Meeting No. 100, 17th March 2005

This meeting was held in the School Hall, Gib Gate School, Mittagong. The Annual General Meeting was to have to have been held on this occasion but it had to be postponed until the April meeting.

The speaker for this meeting was Professor John Shine, Executive Director of the Institute of Medical Research. In his lecture, entitled 'Humanity's Future - Understanding our Genome', Professor Shine spoke of the completion of the human genome sequence and the effects this is having on medicine and pharmacy and the benefits this can have on our futures. 39 people were at this meeting.

As usual the continuing success of the Branch is due the effort and co-operation of many people. In particular I would like to thank Ms Julie Gillick, Head of Winifred West Schools Ltd. and her staff who have generously provided our venue, the management of the Fitzroy Inn who allowed us to use one of their rooms for a meeting and for their wonderful after meeting dinners, the many very fine lecturers who visited us, the Council of the Royal Society of N.S.W. Society for its support and the local Branch Committee for their hard work.

H.R. Perry
Chairman, SHB
31st March, 2005

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The Royal Society of New South Wales

Financial Statements

for the Year Ended 31 December 2004

The Royal Society of New South Wales
Council's Financial Report for 2004

Your Council Members submit the following financial statements of the Society for the year ended 31 December, 2004.

COUNCIL MEMBERS

Mr D.A. Craddock
Prof J.C. Kelly
Dr R.A. Creelman
Assoc. Prof. W.A. Sewell
Mr J. Hardie
Dr M. Lake
Ms K. Kelly
Mr C.M. Wilmot
Mr M. Wilmot
Mr R. Woollett
Prof. W.E. Smith
Prof. P.A. Williams
Co-opted Council Members: Ms J. Rowling
Ms A. Binnie
Dr E. Baker
Ms C. van der Leeuw
Ms M. Haire
Ms R. Stutchbury

PRINCIPAL ACTIVITIES

The principal activities of the Society during the year were: organisation of meetings and publication of the Journal & Proceedings and the Bulletin.

SIGNIFICANT CHANGES

No significant change in the nature of these activities occurred during the year.

OPERATING RESULT

The deficit for the year amounted to $ 7,086 (2003 – surplus $4,518)
Signed in accordance with a resolution of the members of the Council.

President ______________________________

Hon. Treasurer ______________________________

Dated this 6th day of April 2005, Sydney.

THE ROYAL SOCIETY OF NEW SOUTH WALES
STATEMENT OF FINANCIAL PERFORMANCE
FOR THE YEAR ENDED 31 DECEMBER 2004

	2004 $	2003 $
INCOME		
Membership subscriptions	11,944	14,283
Journal subscriptions	3,776	3,596
Investment income	4,751	5,187
Donations	29,700	13,600
Eureka award	3,000	4,000
Other	244	822
TOTAL INCOME	53,415	41,488
EXPENSE		
Accounting & auditing fees	2,010	1,500
Bulletin costs	1,355	2,047
Depreciation	582	369
Eureka prize	10,000	10,000
Insurances	933	886
Journal & proceedings publication	13,055	4,599
Monthly meetings	3,795	1,777
Joint Royal Society Dinner	407	0
Office expenses	6,090	2,133
Provision for doubtful debts	220	1,366
Salaries & wages	19,200	11,200
Superannuation	2,160	576
Telephone	694	517
TOTAL EXPENSES	60,501	36,970
SURPLUS FOR THE YEAR	-7,086	4,518
Balance at 1 January, 2004	170,669	166,151
Accumulated Funds at 31 December 2004	$ 163,583	$ 170,669

THE ROYAL SOCIETY OF NEW SOUTH WALES
STATEMENT OF FINANCIAL POSITION
FOR THE YEAR ENDED 31 DECEMBER 2004

	Note	2004 $	2003 $
ASSETS			
Current Assets			
Cash at bank	2	42,300	44,847
Investments	3	2,148	2,142
Receivables	4	5,597	6,551
Total Current Assets		50,045	53,540
Non Current Assets			
Investments	3	155,033	148,542
Property & equipment	5	15,929	15,075
Total non-current assets		170,962	163,617
TOTAL ASSETS		221,007	217,157
LIABILITIES			
Current Liabilities			
Creditors and accruals	6	2,810	2,845
Total Current Liabilities		2,810	2,845
Non-Current Liabilities			
Creditors & accruals		-	-
Total Non-Current Liabilities		-	-
TOTAL LIABILITES		2,810	2,845
NET ASSETS		$ 218,197	$ 214,312
MEMBERS' FUNDS			
Accumulated funds		163,583	170,669
Library fund	7	25,316	16,082
Trust funds	8	27,115	26,036
NSW Centenary of Fed. Fund	13	(98)	(98)
Studentship fund	14	2,281	1,623
TOTAL MEMBERS' FUNDS		$ 218,197	$ 214,312

The accompanying notes form part of these accounts.

THE ROYAL SOCIETY OF NEW SOUTH WALES
NOTES TO AND FORMING PART OF THE ACCOUNTS
FOR THE YEAR ENDED 31 DECEMBER 2004

1. Statement of Accounting Policies

These financial statements are a special purpose financial report prepared for use by the Council and Members of the Society. The council has determined that the Society is not a reporting entity.

The financial report has been prepared in accordance with customary accounting practices on an 'accruals basis and on historic costs, taking no account of changing money values, or current' valuations of non current assets. Sums owing by members who have subsequently resigned or died or who have been removed from the membership list under Rule 5 (b) have been expensed under provision for doubtful debts.

	2004 $	2003 $
2. Cash		
Cash on hand	648	815
Cash at bank	41,652	44,032
	42,300	44,847
3. Investments		
Current		
Library fund	2,148	2,142
Non-Current		
Term deposit - St George a/c no. 551555467	155,033	148,542
4. Receivables		
Membership fees	3,090	5,510
Provision for doubtful debts	(1,586)	(1,366)
Eureka prize receivable	4,400	2,200
Journal subscription in arrears	(307)	207
	5,597	6,551
5. Property		
Office equipment & furniture at cost	13,836	12,400
Less accumulated depreciation	(11,507)	(10,925)
	2,329	1,475
Library at 1936 valuation	13,600	13,600
	15,929	15,075
6. Liabilities		
Current - Creditors and accruals		
Membership fees prepaid	478	65
Journal subscriptions pre-paid	476	2,113
Sundry creditors PAYG 1584 + Super 432	3,183	1,584
GST payable/(refundable)	(1,327)	(917)
	2,810	2,845

	Note	2004 $	2003 $
7. Library Fund			
Balance at 1 January		16,082	14,931
Donations & interest		9,234	1,151
		25,316	16,082
Library purchases & expenses		-	-
Balance at 31 December		25,316	16,082
8. Trust Funds			
Included in Trust Funds are:			
Clarke Memorial Fund	9	4,140	3,978
Walter Burfitt Prize	10	8,454	8,119
Liversidge Bequest Fund	11	3,870	3,719
Olle Bequest Fund	12	10,651	10,220
Total Trust Funds		27,115	26,036
9. Clarke Memorial Fund			
Capital		5,000	5,000
Revenue			
Income		162	178
Expenditure		-	-
Surplus		162	178
Balance at 1 January		(1,022)	(1,200)
Balance at 31 December		(860)	(1,022)
Total Fund Capital & Expenditure		4,140	3,978
10. Walter Burfitt Prize Fund			
Capital		3,000	3,000
Revenue			
Income		335	364
Expenditure		-	-
Surplus		335	364
Balance at 1 January		5,119	4,755
Balance at 31 December		5,454	5,119
Total Fund Capital & Expenditure		8,454	8,119

	Note	2004 $	2003 $
11. Liversidge Bequest Fund			
Capital		3,000	3,000
Revenue			
Income		151	166
Expenditure		-	-
Surplus		151	166
Balance at 1 January		719	553
Balance at 31 December		870	719
Total Fund Capital & Expenditure		3,870	3,719
12. Olle Bequest Fund			
Capital		4,000	4,000
Revenue			
Income		431	458
Expenditure		-	-
Surplus		431	458
Balance at 1 January		6,220	5,762
Balance at 31 December		6,651	6,220
Total Fund Capital & Expenditure		10,651	10,220
13. Centenary of Federation Fund			
Revenue			
Income		-	-
Expenditure		-	-
Surplus		-	-
Balance at 1 January		(98)	(98)
Balance at 31 December		(98)	(98)
14. Studentship Fund			
Revenue			
Income		658	477
Expenditure		-	-
Surplus		658	477
Balance at 1 January		1,623	1,146
Balance at 31 December		2,281	1,623

THE ROYAL SOCIETY OF NEW SOUTH WALES STATEMENT BY MEMBERS OF THE COUNCIL

In the opinion of the Council the financial statements:

1. present fairly the financial position of The Royal Society of New South Wales as at 31 December, 2004 and the results for the year ended on that date in accordance with Australian Accounting Standards and other mandatory professional reporting requirements, and

2. at the date of this statement, there are reasonable grounds to believe that the Society will be able to pay its debts as and when that fall due.

This statement is made in accordance with a resolution of the council and is signed for on behalf of the Council by:

President ____________________________

Hon. Treasurer ____________________________

Dated this 6th day of April 2005
Place: Sydney

THE ROYAL SOCIETY OF NEW SOUTH WALES INDEPENDENT AUDIT REPORT TO THE MEMBERS

Scope

I have audited the financial statements, being the Statement of Financial Performance, Statement of Financial Position & Notes to and forming part of the financial statements of The Royal Society of New South Wales for the year ended 31 December, 2004. The Council is responsible for the financial statements. I have conducted an independent audit of these financial statements in order to express an opinion on them to the members.

My audit has been conducted in accordance with Australian Auditing Standards to provide reasonable assurance as to whether the financial statements are free of material misstatement. My procedures included examination, on a test basis, of evidence supporting the amounts and other disclosures in the financial statements and the valuation of accounting policies and significant estimates. These procedures have been undertaken to form an opinion as to whether, in all material respects, the financial statements are presented fairly in accordance with Australian Accounting standards and other professional reporting requirements so as to present a view which is consistent with my understanding of the Society's position and the results of its operations.

The audit opinion expressed in this report has been formed on the above basis.

Audit Opinion

In my opinion, the financial statements present fairly in accordance with Australian Accounting Standards and other mandatory reporting requirements the financial position of The Royal Society of New South Wales as at 31 December, 2004 and the results of its operations for the year then ended.

(original signed by the Auditor)

G.M. Green
Registered Auditor No. 15169 (original signed by the Auditor)

Dated: 21^{st} February, 2005
Place: Sydney

Notes

Notes

NOTICE TO AUTHORS

Manuscripts should be addressed to The Honorary Secretary, Royal Society of New South Wales, Building H47 University of Sydney NSW 2006.

Manuscripts will be reviewed by the Hon. Editor, in consultation with the Editorial Board, to decide whether the paper will be considered for publication in the Journal. Manuscripts are subjected to peer review by an independant referee. In the event of initial rejection, manuscripts may be sent to two other referees.

Papers, other than those specially invited by the Editorial Board on behalf of Council, will only be considered if the content is substantially new material which has not been published previously, has not been submitted concurrently elsewhere nor is likely to be published substantially in the same form elsewhere. Well-known work and experimental procedure should be referred to only briefly, and extensive reviews and historical surveys should, as a rule, be avoided. Letters to the Editor and short notes may also be submitted for publication.

Three, single sided, typed copies of the manuscript (double spacing) should be submitted on A4 paper.

Spelling should conform with "The Concise Oxford Dictionary" or "The Macquarie Dictionary". The Systéme International d'Unites (SI) is to be used, with the abbreviations and symbols set out in Australian Standard AS1000.

All stratigaphic names must conform with the International Stratigraphic Guide and new names must first be cleared with the Central Register of Australian Stratigraphic Names, Australian Geological Survey Organisation, Canberra, ACT 2601, Australia. The codes of Botanical and Zoological Nomenclature must also be adhered to as neccessary.

The Abstract should be brief and informative.

Tables and Illustrations should be in the form and size intended for insertion in the master manuscript - 150 mm x 200 mm. If this is not readily possible then an indication of the required reduction (such as 'reduce to 1/2 size') must be clearly stated. Tables and illustrations should be numbered consecutively with Arabic numerals in a single sequence and each must have a caption.

Half-tone illustrations (photographs) should be included only when essential and should be presented on glossy paper.

Maps, diagrams and graphs should generally not be larger than a single page. However, larger figures may be split and printed across two opposite pages. The scale of maps or diagrams must be given in bar form.

References are to be cited in the text by giving the author's name and year of publication. References in the Reference List should be listed alphabetically by author and then chronologically by date. Titles of journals should be cited in full – not abbreviated.

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